Materials Engineering in Product Design + Manufacture

Materials & Methods

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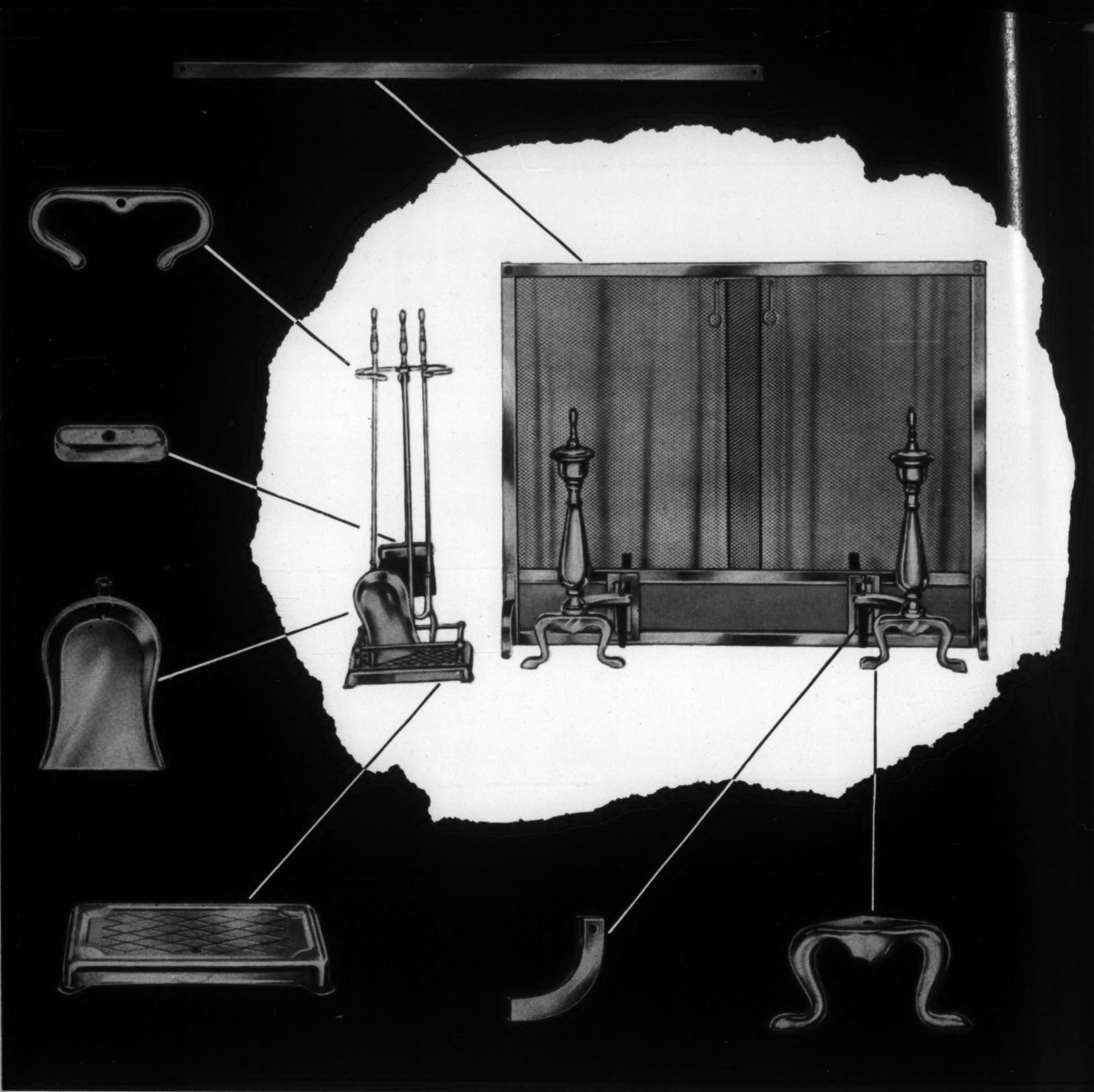

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Materials Engineering in Product Design + Manufacture

Materials & Methods®

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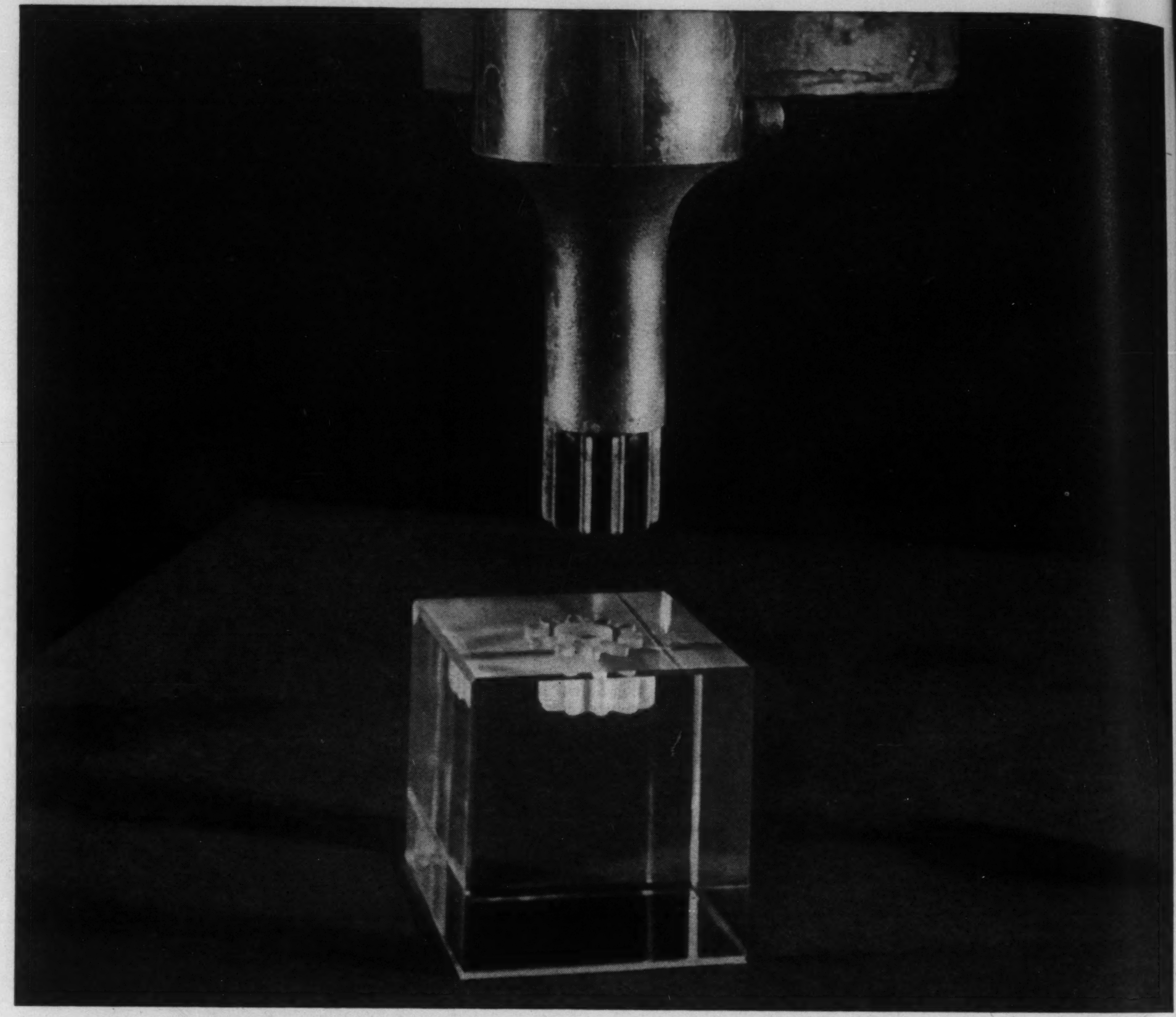
MATERIALS & METHODS TO MOVE — Materials & Methods will move to new and larger quarters either late in June or early in July. Our new address will be:
430 PARK AVENUE, NEW YORK 22, N. Y.

PRICE 50 CENTS A COPY. PAYABLE IN ADVANCE, ONE YEAR, $2.00; TWO YEARS, $3.00; THREE YEARS, $4.00 IN U. S., POSSESSIONS AND CANADA. IN ALL LATIN AMERICAN COUNTRIES: ONE YEAR $10.00; TWO YEARS, $16.00; THREE YEARS, $20.00. ALL OTHER COUNTRIES: ONE YEAR $15.00; TWO YEARS, $25.00; THREE YEARS, $30.00 (REMIT BY NEW YORK DRAFT). COPYRIGHT, 1954, BY REINHOLD PUBLISHING CORPORATION. PRINTED BY PUBLISHERS PRINTING CO., NEW YORK, N. Y. ALL RIGHTS RESERVED. REENTERED AS SECOND CLASS MATTER JULY 19, 1951, AT THE POST OFFICE AT NEW YORK, N. Y., UNDER THE ACT OF MARCH 3, 1879. ESTABLISHED IN 1929 AS METALS AND ALLOYS.



Using high-frequency vibrations and low-cost abrasives, the Ultrasonic Machine Tool carves holes and patterns of all shapes in hard-to-work materials. Development of the tool climaxed more than 10 years of research and experimental work.

How SILENT SOUNDS CUT HOLES you can't drill

This common steel gear bites its way into a glass cube as smoothly as it would mesh with its mate.

And that's *something*, for chiseling through glass is quite a trick, even with a tool designed for the job.

Yet, as you can see, it's being done right here. And the machine that does it can also sharpen the hard metal tools used to cut other metals. It can cut diamonds without the use of diamond powder. Some day, it may even eliminate the heat-generated pain caused by your dentist's whirling drill, or provide a vastly improved method for breaking up kidney- and gallstones.

Now how does this revolutionary tool work? *By ultrasonic vibration.* It vibrates 27,000 times a second! Every vibration pounds water-borne abrasive against the surface you're cutting, and steadily chisels away tiny particles.

It took time to produce and control these vibrations. Over 10 years of research and trial-and-error experimentation! Then—with the help of Inco Nickel — the successful method was perfected.

Pure nickel, when placed in an electromagnetic field, contracts much more than other commercial metals, and returns to its original length. (Physicists call this "magnetostriction.") It is this motion — stepped up a hundredfold — that produces the vibrations which give the tool its bite.

There are many similar useful qualities found in Inco Nickel Alloys. Between them, pure nickel and Monel provided the key to the problems of the ultrasonic machine tool. Another of our metals may help to open a door now locked to you. Let's get together and work out that problem of *yours* — soon.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

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"KR"® Monel • "S"® Monel • Inconel®
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Carbon Nickel • Duranickel®

INCO

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The Materials Outlook

LEAD AND PVC

The world's largest producer of lead-clad metals has announced its intention to produce large-scale chemical and process equipment from rigid unplasticized polyvinyl chloride. Like the entry of metals producers into the plastic pipe field, it's an indication of industry's growing desire to be in a position to use the material most suitable for a specific application, rather than try to adapt each application to a traditional material.

TITANIUM DEVELOPMENTS

Latest advance in the search for an inexpensive and uncontaminating mold material for casting titanium is a silica shell mold with a baked-on zirconium oxychloride wash. Castings from such molds show less pinholing and surface contamination, though not appreciably less over-all depth of contamination, than castings from other inexpensive molds. . . . A titanium alloy containing 36% aluminum and said to offer better elevated temperature properties than conventional titanium alloys is currently being investigated. . . . Another recent development is a series of nickel-titanium brazing alloys which appear to make furnace brazing of titanium practical. Current diffusion filler alloys tend to form intermetallic layers of brittle compounds during the relatively long heating periods needed in furnace brazing as compared to torch or induction brazing. So far the new fusion alloys have been made only in powder form. Brazed joints of 40,000 to 70,000 psi ultimate shear strength have been obtained.

SYNTHETIC MICA

Synthetic mica is now being made in continuous sheets in experimental quantities. The sheet is a combination of low-melting and high-melting mica, the low-melting component being used to bind the sheet together. Availability of synthetic mica has been awaited with great interest since it is expected eventually to free this country from dependence on foreign sources for this material.

VANADIUM

Creep rupture data is now being gathered on vanadium alloys representing at least four ternary systems. Although vanadium alloys do not seem to offer special advantages over other materials, especially titanium, at lower temperatures, its properties at elevated temperatures up to 1650 F are believed to be outstanding.

TUMBLING

Something new in barrel finishing: a 4-ft revolving disk on which can be mounted up to 25 barrels at any angle that turn at speeds from 11 to 28 rpm. Improved flexibility of both tumbling action and production control are claimed.

(Continued on page 4)

The Materials Outlook *(continued)*

NEW ELECTRICAL LAMINATES

Two new paper-base plastic laminates have been announced. One is a polyester laminate of NEMA Grade XXP that comes in rolls of continuous lengths up to 150 ft and has a glossy white opaque finish. The stock is 36 in. wide and is available in thicknesses ranging from 0.025 to 0.062 in. . . . The other is a polyester-modfiied melamine laminate with arc resistance about midway between that of paper-base phenolics (NEMA Grade XXX) and paper-base melamines (NEMA Grade XX-M). Chief advantage of this material is its machinability; thicknesses up to ⅛ in. can be punched, compared to a maximum of 1/32 in. for straight melamine laminates.

NEW SURFACING METHODS

A rapid and selective technique of producing special resistant surfaces on ferrous materials has been developed. The metal is painted with a mixture of an enamel frit and a compound of chromium or silicon, heated to 1800-1900 F for 15 min, and cooled. The resulting enamel is then cracked off, leaving a chromized or siliconized surface. . . . A new hard surfacing method utilizes a nickel-chromium-boron powder applied cold and fused on in a dry hydrogen atmosphere. Thicknesses from 0.0015 to 0.010 in. and hardness up to Rc 60 are obtainable, and the resulting surface is claimed to be smooth. The coating resists wear, erosion and corrosion.

PLASTIC TRUCK

A prototype plastic-body delivery truck is now being service-tested. The truck body has 19 parts and weighs 650 lb compared to 1700 lb for an aluminum-steel type. The same economies achieved in the manufacture of sports car bodies of reinforced plastics are expected to be realized with other types of vehicles where only a limited number of bodies of a particular design are desired.

NEW WELDING TECHNIQUE

A smooth, sound weld surface can now be obtained on the inaccessible side of a butt joint on plate or pipe without using backing rings or bars. Filler rod of controlled dimensions and composition is inserted between the root faces and welded in by the inert-gas-shielded tungsten arc method.

TRENDS IN ELECTROLYTIC TINPLATE

A thickness of 1 lb per base box for electrolytic tinplate is now fairly standard. The thinner plates previously used did not perform well in some applications. . . . Differentially coated electrolytic tinplate is now available in quantity. With a 1-lb coat on one side and a 0.25-lb coat on the other, the dual-coated plate is especially suitable for cans needing high corrosion resistance on the inside and only ordinary atmospheric resistance on the outside. Neither side is lacquered.

ALUMINUM SHOT

Aluminum shot, about ⅜ in. dia and 99.3% pure is now being marketed for alloying with zinc for die casting materials, deoxidizing steels, and for use in various chemical industries.

Another new development using

B. F. Goodrich Chemical **raw materials**

B. F. Goodrich Chemical Company does not make this rigid vinyl pipe. We supply the Geon resin only.

Right in the groove - rigid vinyl pipe

THIS is a part of a 3-mile installation of rigid vinyl plastic pipe in the oil fields of Ellis County, Kansas. It carries hot salt water—a corrosive by-product of crude oil—from a separating tank to a deep disposal well.

Oil company engineers chose *high-impact* rigid vinyl pipe made from Geon resin because it won't corrode, can stand roughest handling and has better chemical resistance. Another advantage: Money is saved in ditching operations for other pipe made of brittle materials must be cradled in a more costly graded ditch to avoid damage.

This high-impact rigid vinyl pipe has so many advantages that it may suggest a use to you or may give you an idea for an equally successful product. There are scores of other uses for Geon materials—from rigid sheets and panels to flexible colorful upholstery, wire insulation, durable flooring, sponge and many more. For information on Geon materials, please write Dept. GN-6, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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Geon
Polyvinyl Materials
A DIVISION OF THE B F GOODRICH COMPANY

GEON RESINS • GOOD-RITE PLASTICIZERS . . . the ideal team to make products easier, better and more saleable

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON colors

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MATERIALS ENGINEERING News Digest

Sheet Metal and Drawing Stock Produced from Powders

Papers Read at Metal Powder Show Describe Techniques

Highlighting the technical sessions at the Metal Powder Show in Chicago, April 26-27, were two papers revealing the latest advances in the use of powder metallurgy techniques to produce sheet metals and drawing stock from metal powders. Nearly eight hundred metal powder producers, molders of metal powder parts, and users of powder metallurgy products attended the show and sessions to witness and hear about the latest developments in this fast growing field.

An up-to-date review on "The Manufacture of Sheet Materials from Metal Powders" was given by W. D. Jones, Powder Metallurgy, Ltd., (London, England). According to Mr. Jones, we are entering a period in which rapid developments will take place in the continuous manufacture of sheets, rods, tubes, and extruded sections. Perhaps the most rapid strides are being taken now with iron and copper powders. In this country, production of copper powder sheets by a new rolling technique has already started. With this method, the copper powder is fed into a set of rolls which forms it into strip. The strip is then passed through a sintering furnace. The powder is obtained from scrap using a chemical leaching process. The economic advantage of powder rolling results from the fact that fewer rolling and annealing operations are required as compared to the older conventional methods. In general, the properties of rolled copper powder strip are equal to those of conventionally produced copper strip.

According to the author, "alloying by interdiffusion of powders presents no difficulties and we can reasonably expect, shortly, the development of powder rolling techniques in such alloys as cupro-nickel bronzes, stainless steels and aluminum alloys." Mr. Jones also stated that "heat resisting alloy sheets seem likely to have an important future. Some of them, which may present rolling difficulties because of low green strength are most attractively handled with a powder flame spray gun, especially where either comparatively small quantities are involved, or special shapes are called for. The process is particularly suited for the manufacture of porous sheet materials, and odd shapes have been made by spraying the heat resistant alloys on to both sides of a fine wire mesh as a carrier. In sheet production by spraying of Vitallium, stainless steels, Nimonic, etc., the operating costs are entirely reasonable especially if odd shapes and sizes are involved."

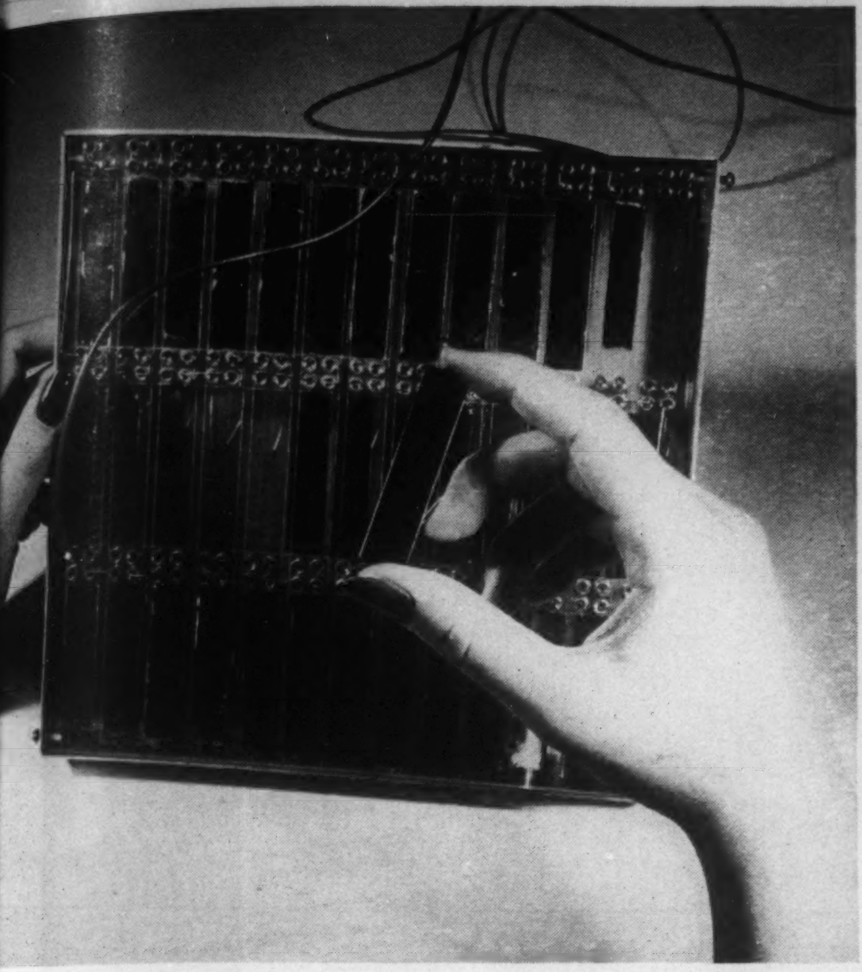
Another development also concerned with the production of metal powder materials was described in the paper "Semi-Formed Drawing Stock by Powder Metallurgy", by R. S. Steinitz, American Electro Metal Corp. and Frank Zaleski, Frankford Arsenal. According to the authors, use of semi-formed metal powder drawing stock will have the advantages of reducing scrap and eliminating a number of drawing and annealing steps. Still in the developmental stages, the method involves molding of metal powder preforms in the shape of cups. The molded cups are sintered, coined and resintered to supply pieces suitable for drawing. Work to date has been concentrated on producing cartridge cases, but the method should be applicable to a wide variety of other products. (*Watch for article in M&M on this subject soon—The Editors.*)

Marking the celebration of their Tenth Anniversary, the members of the Metal Powder Association elected new officers at their annual meeting held in conjuction with the show. Paul E. Weingart, American Metal Co., Ltd., was elected president; William E. Cairnes, Radio Cores, Inc., was elected chairman of the board; and Robert L. Ziegfeld was elected secretary-treasurer.

Steel Founders Society Product Development Contest

The Steel Founders Society of America has announced its 1954 product development contest. The society will award six prizes totalling $3500 to the best examples of product improvement achieved through the design, fabrication or new use of steel castings. Two first prizes of $1000 will be given the two winners of the national contest. Entries may be made by individuals or groups. Closing date of the contest is November 1, 1954.

Complete information on eligibility, judging factors, rules and conditions is available without obligation from the Product Development Award Committee, Steel Founders Society of America, 920 Midland Building, Cleveland 15, Ohio.



Solar cell, consisting of strips of silicon, generates up to 50 watts per sq yd of surface exposed to sunlight.

Scientists responsible for metallurgical, chemical and physical development of solar battery test output of silicon strips under artificial light.

Silicon Converts Light to Electrical Power

A solar battery with six times the efficiency of any previous photoelectric device has been developed by the Bell Telephone Laboratories. It is the first device to convert light energy directly and efficiently into useful amounts of electricity. The present efficiency of the experimental models of the battery is 6%, but it is expected to rise significantly with improved techniques. Since nothing is consumed or destroyed in the energy conversion process, the cells should have an almost indefinite life as long as they are protected from weathering and corrosion.

The heart of the solar battery is a strip of ultra pure silicon—a semiconductor—with controlled amounts of impurities diffused into its surface. When light strikes the surface of the silicon, its energy frees electrons or creates "holes", which are equivalent to positive electron charges, causing a potential difference to occur across the silicon strip. A number of strips —about the size of razor blades—can be connected electrically to produce greater voltage or current. The output of the battery is roughly 50 watts per sq yd of surface exposed to bright sunlight.

Solar generator units are still a long way from commercial production and will see only experimental service for a number of years, but the achievement of capturing a significant amount of useable power from light represents a milestone that has been long awaited and which may be more significant than the release of nuclear energy in terms of its power potential. Bell scientists see almost immediate use for the cells in such experimental applications as charging storage battery packs in remote locations. They indicated that one of the first trials of the cell will be to supply power for Bell's new transistrized rural carrier system in Americus, Georgia.

The metallurgical and physical hurdles that had to be cleared in the course of the battery development are tremendously important to the whole field of electronics and semiconductors. The refinement of silicon to the extreme purity needed for such a device is a large achievement in itself. Of equal importance is the success in introducing a large area diffusion junction on the surface of the silicon strip. The *p-n* junction is prepared by diffusing precisely controlled amounts of impurities to controlled depth into the surface of the silicon metal by heating in the presence of impurity vapor.

C. S. Fuller of Bell Labs is credited with the development of the diffusion technique which led to the development of the solar cell. G. L. Pearson applied Fuller's large area diffusion junctions to high powered silicon rectifiers and lightning arrestors for communication lines. D. M. Chapin developed the techniques pioneered by Pearson and Fuller to make the large area solar battery.

Fuller's diffusion technique is capable of implanting p-type or n-type layers of impurities in either germanium or silicon. The method is used for both high-power, large-area devices and for devices with more complicated geometries where exceedingly close tolerances are required, such as transistors. Recent developments in crystal purity combined with advances in knowledge of ways to maintain extreme surface cleanliness have removed many of the obstacles which formerly existed in this line of semiconductor research. The ultimate potentials of the diffusion procedure are still being explored, but it is now certain that higher operating temperatures and more rugged components will be made using silicon, which does not suffer germanium's instability at usual operating temperatures of electronic devices.

News Digest

Gov't to Buy Titanium Surplus

Titanium consumption is lagging so seriously behind production at the moment that the Government's Office of Defense Materials is buying up the surplus to keep producers in business. However, it should not be assumed that this situation will continue for long. Most designs incorporating titanium are still in their experimental stage and will not be a large factor in demand for volume quantities of the metal for some time.

Government estimates put the 1954 production of titanium at about 5000 tons, yet the latest study of consumption indicates that a mere 3000 tons will be sufficient for this year's military, aviation, and Atomic Energy Commission requirements. At the current price of $4.72 per lb, the extra 2000 tons of titanium sponge that will be turned out this year represents nearly $19 million worth of material.

Defense Mobilizer Arthur Fleming announced that the government would buy up to 4000 tons of titanium and would hold it in stock for eventual resale to qualified manufacturers of military equipment. Eventually, the government plans to open the stock for unrestricted civilian use, but at present up to 90% will be reserved for strategic purposes only.

The ODM considers the titanium stockpile a "working inventory." It will assure manufacturers of a sizeable supply when needed as new designs are phased-in the defense program, as well as encourage present producers to keep up a high rate of output. The inventory will be handled on a first in first out basis to keep the supply turning over so that the entire inventory will always consist of titanium sponge of current specifications.

Why Use Lags

In view of the great excitement and enthusiasm that has accompanied the development of titanium from a laboratory curiosity to an accredited structural metal of outstanding strength weight ratio—all within five years—the sudden excess of titanium may seem to be paradoxical. There

(Continued on page 214)

M&M's new headquarters. **Next month, Materials & Methods, with its parent organization, Reinhold Publishing Corporation, is moving to larger quarters in the new building pictured above at 430 Park Avenue, New York City. Reinhold Publishing Corporation will occupy three floors of the new, glass-sheathed, air-conditioned structure.**

Emery Roth & Sons, Architects

Committee Will Discuss Vacuum Techniques

The Committee on Vacuum Techniques, a recently formed organization representing a number of industries, universities and manufacturers concerned with high vacuum processes, is sponsoring a high vacuum symposium on June 16, 17, and 18, at the Berkeley Carteret Hotel at Asbury Park, N. J.

The need for a meeting which would have vacuum technology itself as a central theme has resulted in the work of The Committee on Vacuum Techniques in planning the June symposium. The rapid growing use of vacuum techniques in a variety of industries, which include electronics, metallurgical, optical, nuclear, coating, analytical, and chemical, has brought to light the need for vacuum engineers. At the symposium, vacuum specialists will have the opportunity of having vacuum technology discussed in a concentrated fashion rather than mixed with chemical engineering, electrical engineering, metallurgy, or other broad fields in which vacuum techniques are only a small part.

The program, comprising approximately 25 technical papers, will include discussion of nomenclature and standards, new equipment and instruments, fundamental developments in vacuum technology, methods and techniques, and applications and processes. In planning the program, the committee has taken special care to include subjects of practical as well as theoretical importance.

Persons and organizations interested in attending the Symposium are invited to contact The Committee on Vacuum Techniques, Box 1282, Boston 9, Mass.

(Men of Materials on page 11)

Men of Materials . . .

their views on development and utilization of engineering materials in industry

JULIUS J. HARWOOD

Head, Metallurgy Branch, Office of Naval Research, Department of the Navy

"Research scientists have provided so many new materials that we are now in a position to tell designers, 'Here is a material, design around it'. Progress in materials development is such that to reap the full benefit of the characteristics of these new materials in both war materiel and consumer products, new design concepts are essential. If we are to use our resources to the best advantage, there must be complete integration of design and material." So summarizes J. J. Harwood in discussing the current state of materials development. Mr. Harwood, as Chief of the Metallurgy Branch of the Office of Naval Research, has an extensive knowledge of a number of materials fields, some of which might make a traditional metallurgist wonder whether the profession was expanding to include organics and ceramics.

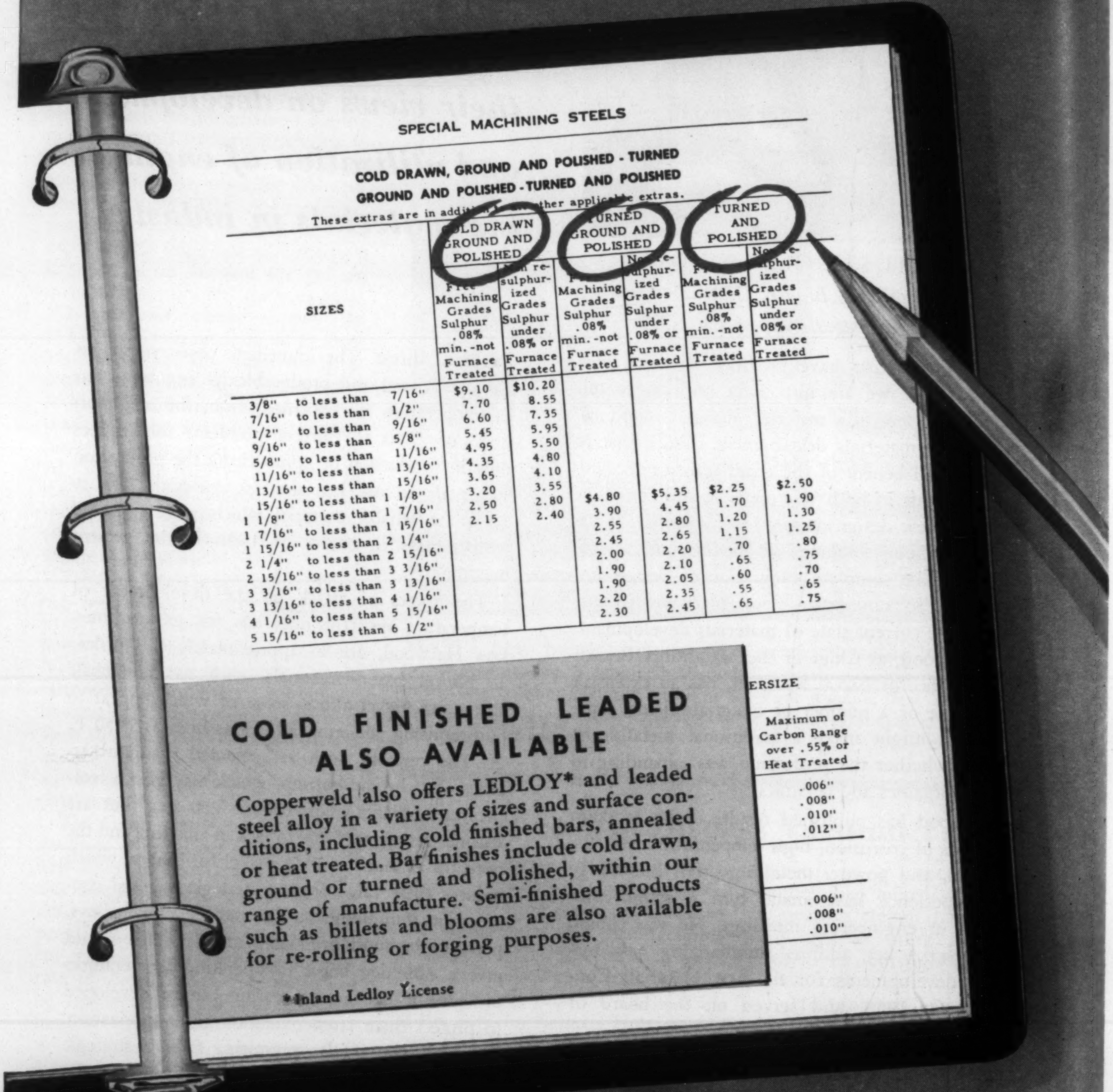
Harwood has published results of his work in the fields of corrosion, high temperature materials, titanium, and powder metallurgy. His knowledge and experience have made him a sought-after speaker at engineering meetings. He was chosen to deliver a key address summarizing new materials developments for the first Materials Conference in 1953, and served on the board of advisors for the 1954 Conference.

Structural strength at high temperatures is, Harwood says, "Unqualifiedly the greatest problem in materials today. . ." The focus of the problem, ". . . because it presents the toughest test for materials ever devised by man and presents the greatest opportunity for increased efficiency at higher temperatures, is the gas turbine." As a long range objective he sets operating temperatures of 2500 to 3500 F for the hot end of the turbine, which would mean temperatures over 1000 F in the last stages of the compressors. The benefit? At least 30% cut in fuel consumption with greatly increased thrust. The immediate objective sought for operational and producable jet engines as far as temperature is concerned, is in the neighborhood of 1850 F. Current problems for engines now in production or approaching the production stage, are to use less strategic materials, and to get some reliable material which will withstand temperatures in excess of 1600 F, the present maximum.

The stages of attack on the development of temperature resistant materials for gas turbines, says Harwood, are in approximately this order: 1. Nickel based materials, such as the cobalt chromium nickel alloys, some of which appear to be promising for temperatures as high as 1750 F. 2. The cermets, such as cemented titanium carbides and chrome borides, which may give a temperature advantage of 100 or 200 deg, but are still not satisfactory due to lack of ductility and the need for as much as 75% nickel for binder, which reduces their value from a strategic material conservation standpoint. 3. The molybedenum alloys, perhaps the most promising of all, which would give a 300 deg boost to operating temperatures provided a satisfactory coating can be developed to protect them from oxidation and vaporization. (Molybdenum is also promising from a strategic standpoint, since it is mined largely within the continental limits of the U. S.). 4. The last alternative to the temperature problem is cooling, and designers of jets are reluctant to use cooled blades because the power taken off the compressor for cooling soon overcomes the advantage of the higher temperatures at which the turbine can be operated. Only extremely efficient cooling methods such as sweat cooling by forcing gas through permeable blades appear to be at all practical at this time.

DON'T FORGET

Aristoloy COLD FINISHED SPECIALS



SPECIAL MACHINING STEELS

COLD DRAWN, GROUND AND POLISHED - TURNED GROUND AND POLISHED - TURNED AND POLISHED

These extras are in addition to other applicable extras.

SIZES	COLD DRAWN GROUND AND POLISHED		TURNED GROUND AND POLISHED		TURNED AND POLISHED	
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3/8" to less than 7/16"	$9.10	$10.20				
7/16" to less than 1/2"	7.70	8.55				
1/2" to less than 9/16"	6.60	7.35				
9/16" to less than 5/8"	5.45	5.95				
5/8" to less than 11/16"	4.95	5.50				
11/16" to less than 13/16"	4.35	4.80				
13/16" to less than 15/16"	3.65	4.10				
15/16" to less than 1 1/8"	3.20	3.55				
1 1/8" to less than 1 7/16"	2.50	2.80	$4.80	$5.35	$2.25	$2.50
1 7/16" to less than 1 15/16"	2.15	2.40	3.90	4.45	1.70	1.90
1 15/16" to less than 2 1/4"			2.55	2.80	1.20	1.30
2 1/4" to less than 2 15/16"			2.45	2.65	1.15	1.25
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3 3/16" to less than 3 13/16"			1.90	2.10	.65	.75
3 13/16" to less than 4 1/16"			1.90	2.05	.60	.70
4 1/16" to less than 5 15/16"			2.20	2.35	.55	.65
5 15/16" to less than 6 1/2"			2.30	2.45	.65	.75

ERSIZE

Maximum of Carbon Range over .55% or Heat Treated

.006"
.008"
.010"
.012"

.006"
.008"
.010"

COLD FINISHED LEADED ALSO AVAILABLE

Copperweld also offers LEDLOY* and leaded steel alloy in a variety of sizes and surface conditions, including cold finished bars, annealed or heat treated. Bar finishes include cold drawn, ground or turned and polished, within our range of manufacture. Semi-finished products such as billets and blooms are also available for re-rolling or forging purposes.

*Inland Ledloy License

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COPPERWELD STEEL COMPANY (Steel Division)
WARREN, OHIO

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Houston 25, Texas

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315 Hollenbeck Street
Rochester, New York

For Export—Copperweld Steel International Company, 117 Liberty Street, New York, New York

For more information, turn to Reader Service Card, Circle No. 327

Materials BRIEFS

Gas Tanks. Nylon fuel cells recently installed experimentally in the wings of a Lockheed Lodestar company plane, are expected to last the life of the aircraft, require minimum upkeep. Plane's fuel capacity was increased 20%.

Preservation. Ships standing in mothballs are being protected from corrosion by shore based rectifiers connected to the ships and to electrodes submerged in mud along the shore. This cathodic protection saves approximately $1500 per yr per ship.

Half 'n Half. A welding stud, half aluminum and half mild steel, has been developed to attach aluminum roofing to metal rafters. The steel end is welded to the rafter, or purlin, and the aluminum end is riveted to the roofing. Result: no galvanic corrosion.

Thulium Camera. Provides one of the least expensive portable sources of radiation for x-ray photographs. Irradiated in the Argonne heavy water reactor, a small bit of thulium in a camera weighing less than 10 lb produces radiation equivalent to 100,000 volt x-rays.

Lighter Cables. The Navy has chosen silicone insulation material for use in shipboard cable. Cables using materials are smaller and lighter without loss of safety factors.

Continuous. Chlorotrifluoroethelene (fluorothene) resins are now being produced by a continuous rather than batch process.

Creep Trouble. Because of high temperature creep problems in supersonic aircraft, it may be necessary to design them for a highly limited life expectancy.

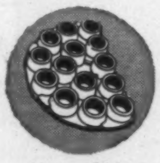
Palm Substitute. Beef tallow can be substituted for palm oil in rolling sheet for hot dip tinning; tallow also is claimed to reduce friction in mill rolls.

Feather Brush. Protein Keratin derived from chicken feathers makes good bristles for paint brushes, can substitute for hard to get Chinese hog bristles.

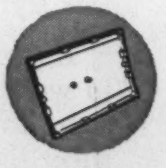
ACE-HIDE®

the new molding material that's both **TOUGH** *and* ***GENTLE***

Ace-Hide acid pail



Molded top for golf bag



Large molding is lid for beverage cooler

Ace-Hide is a new rubber-plastic molding material designed to take a beating without showing it. Its toughness, smoothness, resilience and excellent chemical resistance have already led to wide-spread use for things like chair arm pads, scuff guards, acid pails and golf bag tops.

Ace-Hide is a special blend of rubber with plastic, hence is light in weight and has good electrical and thermal insulating properties. Rigidity and impact strength (to 10.0 Izod) can be varied to suit. Takes inserts well. Surface is smooth, shiny. Does not develop flexing cracks, and ages well. Ace molding facilities offer wide range of sizes and shapes. We'll be glad to make specific recommendations. Write today.

Ace-Hide and many other hard and soft rubber, plastics, and rubber-plastic blends are described in 80 pg. ACE Handbook. Write for your copy today!

ACE® rubber and plastic products

AMERICAN HARD RUBBER COMPANY
93 WORTH STREET • NEW YORK 13, N. Y.

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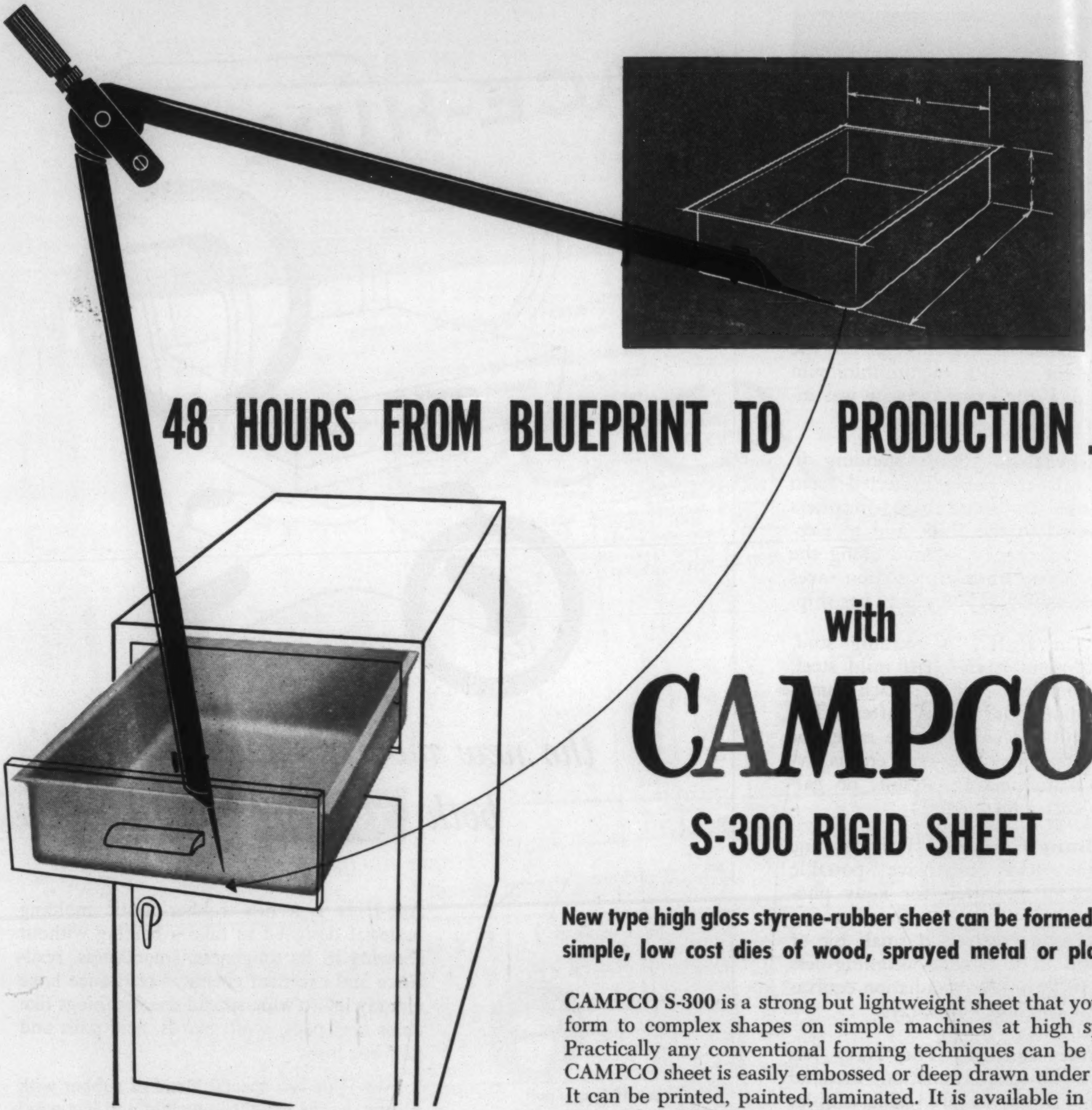

48 HOURS FROM BLUEPRINT TO PRODUCTION...

with CAMPCO S-300 RIGID SHEET

Pilot production mold for drawer shown cost only $25. Mass production metal mold less than $500, and only 3 days to build.

New type high gloss styrene-rubber sheet can be formed with simple, low cost dies of wood, sprayed metal or plaster.

CAMPCO S-300 is a strong but lightweight sheet that you can form to complex shapes on simple machines at high speed. Practically any conventional forming techniques can be used. CAMPCO sheet is easily embossed or deep drawn under heat. It can be printed, painted, laminated. It is available in a full range of translucent or opaque colors.

CAMPCO S-300's brilliant, porcelain-like gloss finish, high impact strength, low cost (26 to 28 cents per square foot in .080″ thickness), excellent dimensional stability, low moisture absorption and good heat resistance to temperatures below boiling, result from the new techniques we use to produce this styrene and rubber alloy.

If you are now making, or contemplate making, a product in wood, glass, rigid vinyl, acetate, fibreboard, rubber, or, in some cases, even injection molded plastics, look at CAMPCO sheet first. It may mean greatly reduced die and production costs. It could mean increased product efficiency. Talk it over with our engineers. There's no obligation. Meanwhile, send in the coupon for full details on this remarkable new plastic sheet.

Widths from 20 to 58 inches
Thicknesses from .005 to .125 inch
Any desired length

CAMPCO DIVISION OF CHICAGO MOLDED PRODUCTS CORP.

Campco Division
Chicago Molded Products Corporation
1026 Normandy Ave., Chicago 35, Illinois

Please send me your Technical Data Bulletin on Campco S-300 Sheet.

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Company____________________

Street____________________

City____________________ Zone________

State____________________

For more information, turn to Reader Service Card, Circle No. 487

General Information

Exposition

The Exposition is being held in the Public Auditorium in Cleveland, June 7 to 10. It will be open to visitors from 1:00 to 6:00 P. M. daily, except Wednesday, the 9th when it will remain open until 10:00 P. M.

The companies exhibiting in the booths include molders, laminators, extruders, fabricators, reinforced plastics products manufacturers, film, sheeting and coated fabrics processors, raw materials suppliers, machinery and equipment manufacturers, tool, die and mold makers, and testing and research laboratories. They are demonstrating new materials, processing methods, and other results of recent research in the plastics field.

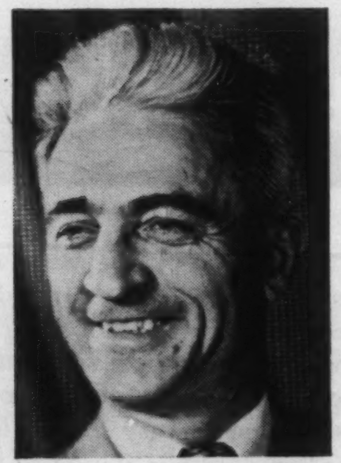
Annual Conference

Meetings of the Conference, running concurrently with the Exposition, will be held in the Cleveland and Statler Hotels from 9:30 to 12:00 Noon on June 7 to 10.

The four industries taking part in the program are the radio and television set makers, the elastomers industry, refrigeration and air conditioning manufacturers and automobile producers. The range of subjects covers new materials in the field, applications, design considerations, forming methods, and a look to the future. Forum type discussions and question and answer sessions help the visitor to take part in the Conference and thereby gain the most benefit from it.

John O'Connell
Consolidated Molded Products Corp., President of The Society of the Plastics Industry, Inc.

William T. Cruse
Executive Vice President of The Society of the Plastics Industry, Inc.



P. H. Grunnagle
Westinghouse Electric Corp., Chairman of 6th National Plastics Exposition Committee of The Society of the Plastics Industry, Inc.

REVERE STEREO VIEWER . . .

precision molded

IN VOLUME PRODUCTION

Revere
Revere

by RICHARDSON

SIX PLANTS

NEWNAN, GA.
MELROSE PARK, ILL.
OGDEN, UTAH
NEW BRUNSWICK, N. J.
INDIANAPOLIS, IND.
TYLER, TEX.

This handsome plastic case for the Revere Stereo Viewer, produced by Richardson, required the molding of four intricate parts. Each part had to be held to close tolerances for easy assembly and good appearance. Special care was needed to prevent warpage, and also to produce a smooth lustrous surface. The Revere Camera Company was extremely pleased with the precision and beauty of the finished job.

Richardson specializes in plastics jobs of this type—jobs which require volume production of precision moldings of the highest quality. Why don't you consult Richardson on your difficult plastics jobs?

Send for Bulletin, "Facts About Plastics"

The RICHARDSON COMPANY

2782-A Lake St., Melrose Park, Illinois (Chicago District)

SEE THE RICHARDSON DISPLAY—BOOTH No. 330
at the NATIONAL PLASTICS EXPOSITION—CLEVELAND, June 7-10

For more information, turn to Reader Service Card, Circle No. 483

Program

of the Annual Conference

Monday, June 7, 10:00 A.M., Cleveland Hotel

Presiding: J. J. O'Connell, President of The Society of the Plastics Industry, Inc.

Address of Welcome by the Honorable Thomas A. Burke, U. S. Senator from Ohio.

Forum: Radio and Television Applications of Plastics.

The Future of Thermosetting Plastics in Television Cabinets, *W. Goss, General Electric Co., Chemical Div.*

Fully Automatic Molding of Radio and Television Components, *L. R. Wanner, Sylvania Electric Products Inc., Parts Div.*

Design Trends in Plastic Radio and Television Cabinets, *Dan H. L. Jensen, Product Manager, Radio Div. Philco Corp.*

Film: Futures Unlimited, produced by Zenith Plastics.

Film describes applications of reinforced plastics and methods of producing them.

Tuesday, June 8, 9:30 A. M. Cleveland Hotel

Two Concurrent Sessions

New Materials Session

Presiding: E. L. Frantz, Apex Electrical Manufacturing Co. Research and Standards for the Plastics Industry, *Dr. Gordon M. Kline, Chief, Organic and Fibrous Materials Div., National Bureau of Standards.*

Expandable Polystyrene Beads—A Unique Plastic Material, *Edwin A. Edberg, Koppers Co., Inc.*

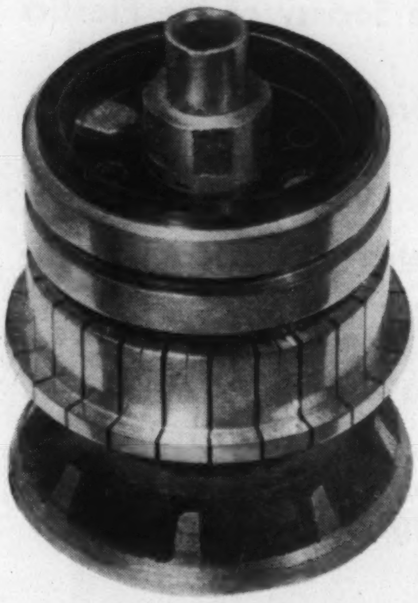
The Effect of High Intense Radiation Fields on the Synthesis and Physical Properties of High Polymers, *Dr. David S. Ballantine.*

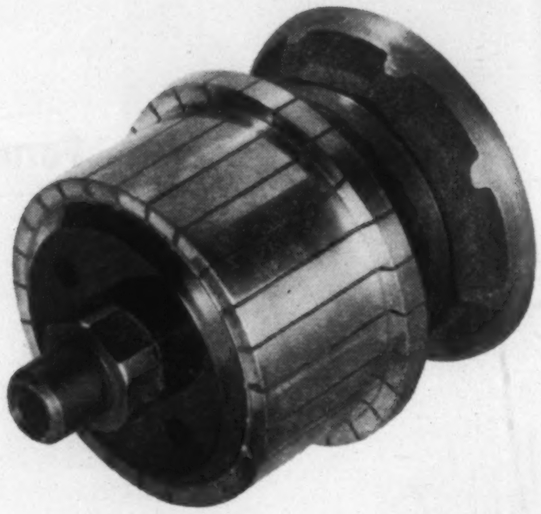
Fission Products Utilization Project, *Brookhaven National Laboratory.*

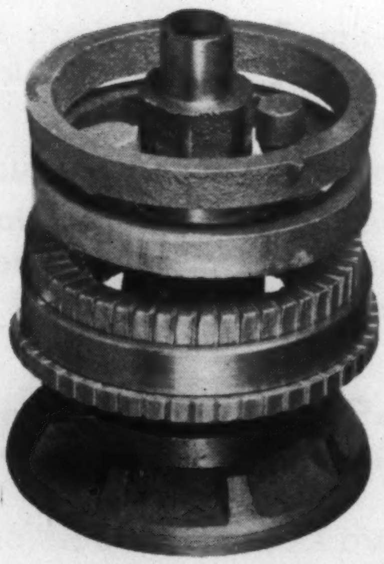
Film: What's a Silicone? *produced by Dow Corning Corp. Describes composition, properties and applications of various forms of silicones.*

(Program continued on page 21)

How'd You Like to Cut the Cost of Commutators . . .







Commutators or other small parts fastened together with bolts can now be successfully and economically bound together by plunger compression molding. It's simple, it's fast . . . You suspend pieces of an assembly (see center photograph) in a plunger mold . . . place the plastic material in the male die and with one stroke, material flows into every part of the assembly. You get a stronger more durable part with exceptional insulating qualities and one that is held to very close tolerances. Ask Ackerman now for help on difficult assemblies that may be done better by plunger molding.

➤ ➤ ➤ *Write for brochure on compression molded plastics—it tells the complete Ackerman story.*

The commutator shown is produced for Kohler of Kohler and is used in diesel standby power units.

Ackerman Plastic Molding
Division of
THE CONSOLIDATED IRON·STEEL MFG. CO.
1290 East 53rd St. • ENdicott 1-4400 • Cleveland 14, Ohio

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Plastics, New Material in Rubber Industry.

Presiding: Frank W. Steere, Jr., Steere Enterprises, Inc.

Moderator, Donald Siddall, U. S. Stoneware Co.

Panel Members: Flexible Materials — Extrusion and Molding Developments, *Frank A. Martin, The Hoover Co.*

Plastisols—Processing and Applications, *Robert P. Molitor, Sun Rubber Co.*

Vinyl Sponge and Foam—Processing and Applications, *George R. Sprague, The Sponge Rubber Products Co.*

Rigid Vinyls and Rubber-Resin Blends—Processing and Applications, *George Laaff, Bolta Products, Div. General Tire and Rubber Co.*

Wednesday, June 9, 9:30 A.M., Hotel Statler

Forum: Refrigeration, Air Conditioning Applications of Plastics.

Presiding: O. Yoxsimer, Westinghouse Electric Corp.

Speakers: Refrigeration and Air Conditioning Applications of Plastics, *J. R. Hertzler, York Corp.*

Domestic Refrigeration Applications of Plastics, *R. E. Wallenbrock, International Harvester Company.*

Potentialities of Plastics for Refrigerator Linings and Large-Area Parts, *E. T. Morton, Midwest Mfg. Co.*

Trends in Molding and Formed Sheets for Door Liners, Freezer Chests, Crispers, Drip Trays, Shelves and Accessories, *Speaker to be announced.*

Panel Discussion: Questions and answers on subject of Formed Sheets vs. Molded Large-Area Parts.

Thursday, June 10, 9:30 A.M., Hotel Statler

Presiding: W. J. McCortney, Chrysler Corp.

Forum: Plastic Applications in Automobiles.

Speakers: Automotive Plastics Applications, *J. K. Totton, Ford Motor Co.*

Cast Dies, *Robert H. Voss, Warren Plastics & Engineering, Inc.*

Reinforced Plastics Tooling, *Fred Lyijynen, Automotive Body Div. of Chrysler Corp.*

Epoxy Plastic Dies, Die Models, Checking Fixtures and Tooling, *George M. Rice, Ren-ite Plastics, Inc.*

The Corvette Plastics Body, *John G. Coffin, Chevrolet Div. of General Motors Corp.*

new ideas come to life in plastics molded by General American

How many of your good ideas have died on a scratch pad? . . . simply because production wasn't practical.

At General American, manufacturers in many industries have seen their new ideas come to life in plastics. Here on the biggest, most versatile plastics production line anywhere, intricate shapes are molded in one "shot". For many products, volume production in plastics becomes a reality for the first time. Tremendous strength is coupled with light weight. Utility and durability team up with colorful new sales appeal never before possible.

For example, this conveyor belt, serving a double battery of injection presses in one of General American's plants, carries some of the world's largest, most intricate and unusual plastics moldings.

Here—yours to use . . . everything you need from development to delivery. Talk over your ideas *now* with a General American engineer.

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● **Facilities unmatched anywhere: injection presses to 300 ounces, compression presses to 2,000 tons, reinforced plastics molding, die making, painting, assembly, packaging**

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6th National Plastics Exposition

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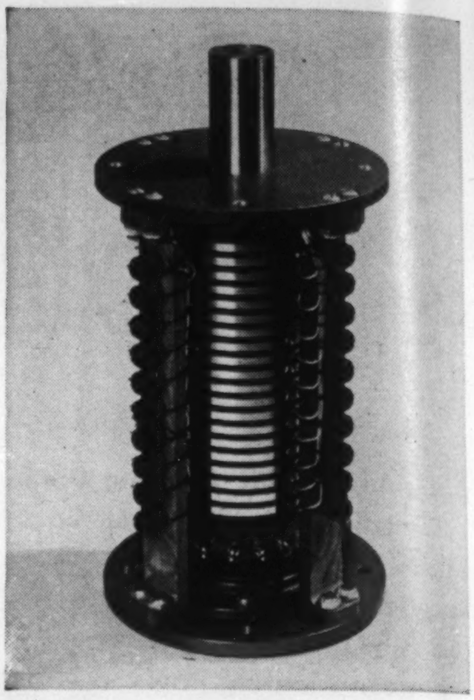
ideas in the making!

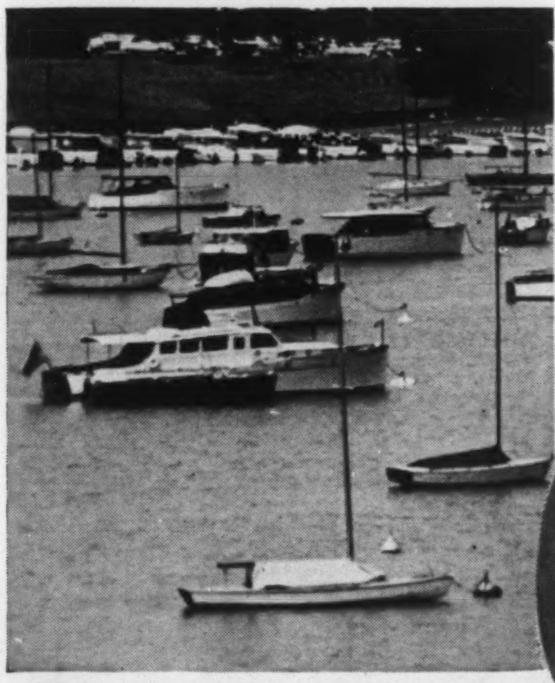
ARALDITE® Epoxy Resins developed by Ciba Research are simplifying manufacturing methods, improving product efficiency and opening new fields of product development. The formulator and the end product producer will want to know more about them. We at Ciba want to help you further your development.

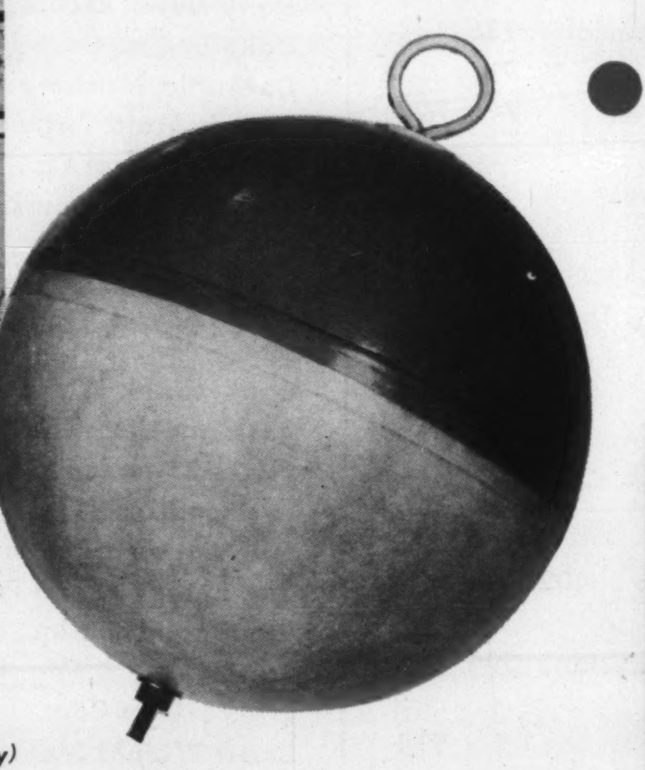


● **SLIP RING ASSEMBLY**

The exceptional casting properties of ARALDITE Resins are demonstrated in this unit designed to operate with strain gauges or radar equipment. ARALDITE Epoxy Resins provide high dielectric strength, arc and humidity resistance which permit a current capacity of 5 amperes per ring.

(Courtesy Airflyte Electronics)





● **ARALDITE IMPREGNATED MOORING BUOY IS STRONG . . . LIGHT . . . WEATHER-PROOF AND SINK-PROOF**

(Courtesy United Pattern Company)

One-seventh the weight of a steel buoy of comparable size including the unicellular filling beneath the surface skin, this newest idea in modern maritime equipment eliminates hull-scuffing damage and is functionally superior in every other way. Since color is "built-in" with salt-water corrosion resistant laminate, it stays bright and new looking, thereby minimizing maintenance. All these advantages suggest a wide range of new and improved product development in which ARALDITE Resins may prove the answer for you.

● **600 VOLT TRANSFORMER TYPE TWM**

This example of ARALDITE Resin encapsulating insulation shows how completely it may be applied to encompass coils in housing in an application where rugged use can be expected for the entire life of the unit. *(Courtesy Allis-Chalmers)*

SEND THIS COUPON . . . or write us on your company letterhead . . . for complete technical data on the physical properties and recommended procedures for the successful use of Araldite Resins for your fabricating needs.

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MM-2

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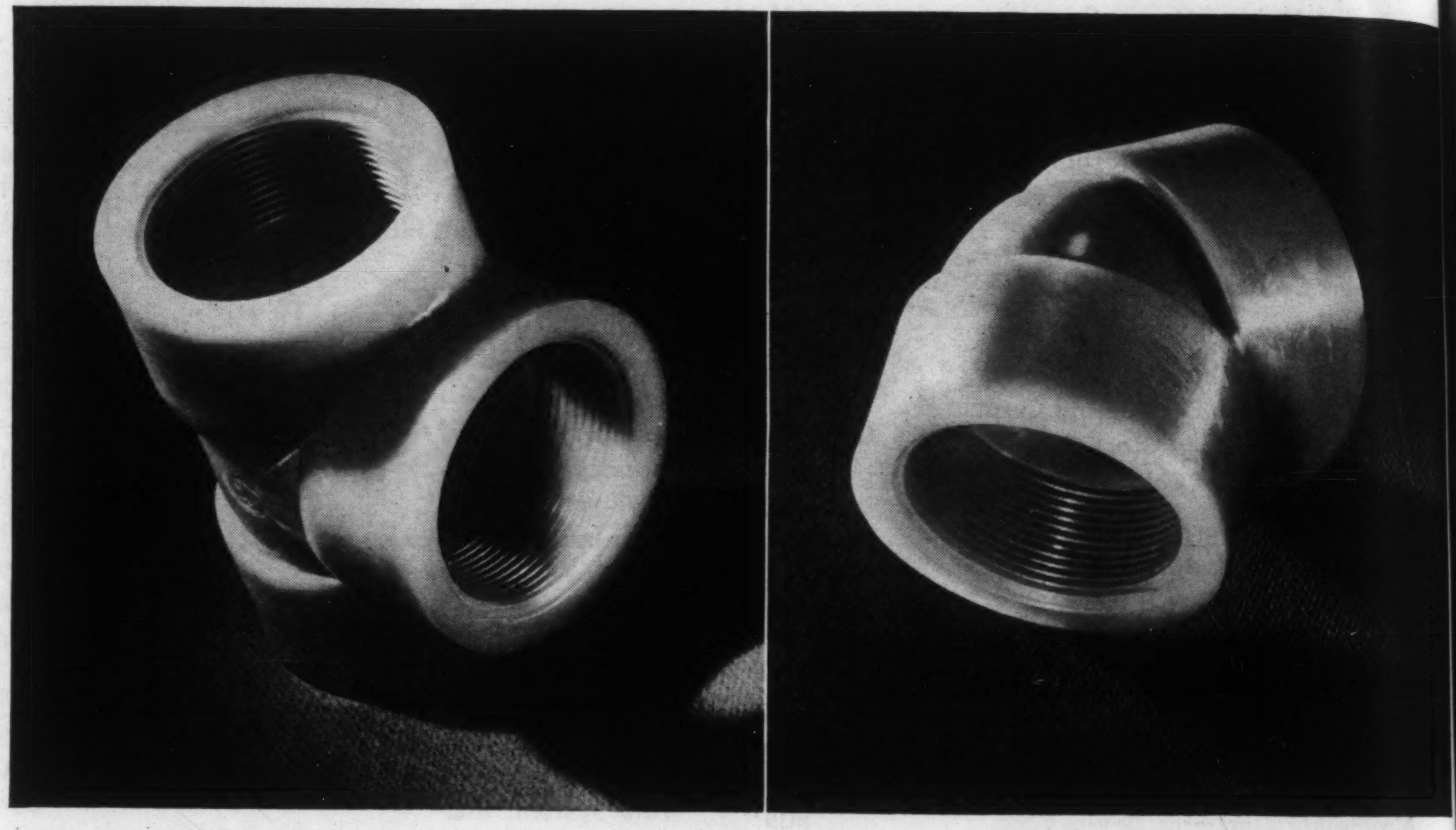
INJECTION MOLDED



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THE development of *injection molded* Unplasticized P.V.C., made from Exon 402-A is another indication of the wide versatility of this new material of construction. This achievement makes possible the manufacture of corrosion-resistant construction materials of countless sizes and shapes—produced quickly, with high strength and at low cost.

Now rigid pipe fittings of Standard I.P.S. sizes ½″ through 4″, slip-fit and threaded, are being produced on a Jackson & Church press utilizing the Hendry pre-plasticizing process.

Using Firestone Exon 402-A as the basic material, Jackson & Church, Saginaw, Mich., are turning out completely uniform, strain-free products with excellent chemical resistance and inertness.

Whenever your Unplasticized P.V.C. applications call for injection molding, Exon 402-A can provide the qualities of toughness and corrosion-resistance to the final product. Consider what this new material of construction in injection molded form can do for you. Contact Firestone today for complete details about Exon 402-A—its uses, methods and advantages.

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Corrosion-Resisting Coatings. Carboline Co., 4 pp, ill. No. 100. A reference data sheet in chart form to aid in selecting the proper synthetic corrosion-resistant coating according to base material and conditions of use. Includes specifications and number of coats, estimated service life, material cost per sq ft, method of application, etc. (21)

Weldments. Continental Steel Foundry Co., 14 pp, ill. Describes facilities for assemblies and sub-assemblies of welded steel plate, structural shapes, castings or composite groupings. (23)

Seamless Metal Hose. DK Manufacturing Co., Inc., 10 pp, ill., No. 100. Describes seamless metal hose made from thin wall tubing in stainless steel, bronze, Monel, nickel and steel for high pressure, high temperature and corrosive applications. (24)

Titanium Carbide Cermets. Firth Sterling, 2 pp, No. 501. Describes the high temperature material composed of titanium carbide with nickel metal binder capable of withstanding temperatures in the range of 1500 to 2000 F. Includes chart of properties at high temperature, information on fabrication, joining and applications. (25)

Reducing Atmosphere Generators. Gas Atmospheres, Inc., 4 pp, ill, No. R-352. Atmosphere generators for industrial applications such as bright hardening, annealing, gas carburizing and sintering. (26)

Electric Heaters and Heating Devices. General Electric Co., 60 pp, ill, No. GEC-100E. G-E's general catalog of electrical heating units and associated control equipment. Includes process and application index. Charts of specific heats and heat loss through various insulated and non-insulated equipment. (27)

Radiography. General Electric Co., X-Ray Dept. A new house organ, "Radiation Digest," devoted to industrial x-ray applications and commercial irradiation techniques. Contains news of the field and feature articles. Published quarterly. (28)

Sandwich Material. Goodyear Aircraft Corp., 36 pp, ill. Describes sandwich structures consisting of thin face material bonded to thick low-density cores of balsa, paper or metal honeycomb, fiberglass and foamed synthetics for use in structural, decorative and other applications. (29)

Pyrometers. Illinois Testing Labs, Inc., 6 pp, ill. Thermoelectric pyrometer for precision measurements of temperatures beyond 1000 F. (30)

Beryllium Copper. Instrument Specialties Co., Inc., 8 pp, ill, No. 8A. Standard spring components of beryllium copper for the electronics industry. Describes kits available to design engineers. (31)

Insulating Varnish. Irvington Varnish & Insulator Div., Minnesota Mining & Mfg. Co. A new general catalog on complete lines of insulating varnishes. Also contains a section "How to Use Insulating Varnishes." (32)

Welded Tubing. Jones & Laughlin Steel Corp., 16 pp, ill. Applications of electrically welded steel tubing, bending and finishing data, tolerances, weight-per-foot tables and other information useful in selecting tubing. (33)

Stainless Steel Castings. Kolcast Industries, Inc., 4 pp, ill. Large stainless steel precision castings made by the frozen mercury process. (34)

Foam Polystyrene. Koppers Co., Inc., 10 pp, No. C-4-200-T. Describes expandable polystyrene beads and polystyrene foam. Includes physical and chemical property listings, suggested applications, molding data and instructions for use of adhesives with the material. (35)

Precipitation Hardening Steels. Latrobe Steel Co., 6 pp, ill. Properties of Cascade precipitation hardening die steel for plastic molds, zinc die-casting dies and holding blocks. (36)

Alloy Metals. Littleford Bros., Inc., 4 pp, ill. Facilities for fabricating large assemblies and small parts from various metal alloys. (37)

Glass Fiber Laminates. Lunn Laminates, Inc., 24 pp, No. LL-54-120. A comprehensive study of glass fiber laminates for the manufacture of shell structures. Charts, equations and diagrams for shell structure manufacture using glass fiber cloth, rovings or mats and polyester or other types of resins. (38)

Metal Cleaning. Magnus Chemical Co., Inc., 8 pp, ill, No. 704-AL. Metal cleaning machines described in bulletin "Metal Parts Batch Cleaning in Minutes." (39)

Insulating Material. Mica Insulator Co. Catalog of standard electrical insulating materials. (40)

Bronze and Copper Castings. National Bearing Div., American Brake Shoe Co., 24 pp, ill. Cast bronze and copper products for general industry described. Charts of composition, analyses, properties and applicable specifications of National's copper, babbit, bronze and aluminum alloys. (41)

Iron Powder. National Radiator Co., Technical Data Sheets PMS 28A and 28B. Chemical and physical characteristics of Plast-Iron B-212, a reduced-oxide iron powder for compacting parts with high tensile strength. Charts include strengths and other properties with and without the use of copper infiltration. (42)

Appliance Insulation. Owens-Corning Fiberglas Corp., 8 pp, ill, No. EA6.C2. Insulation for controlling heat, cold and sound in home appliances. A chart of appliance types and type of insulation necessary. (43)

Molded Rubber. Parker Rubber Products Div., Parker Appliance Co., 4 pp, ill, No. 5201A1. Custom molding facilities for rubber parts. (44)

Extruded Thermoplastics. Pyramid Plastics, Inc., 4 pp, ill. Facilities for extruded rods, shapes, strips, tubes, tape and sheets. Application of continuous plastic coatings and fabrication of complete assemblies. (45)

Metal Heating and Heat Treatment Furnaces. R-S Furnace Corp., 8 pp, ill, No. 200. Descriptions and applications of car hearth, pit, roller hearth, belt, chain, pusher and "Hi-Head" furnaces. (46)

Adhesives. Rubber & Asbestos Corp., 2 pp., ill. Covers a full range of adhesives with Mylar polyester film. Includes chart of adhesives required for different base materials. (47)

Perforated Steel. Joseph T. Ryerson & Son, Inc., 4 pp, ill, No. 50-2. Perforated steel sheets and plates for safety, ornamental and screening purposes. Illustrates patterns in stock and gives instructions for ordering custom perforated material. (48)

Protective Coatings. Saran Protective Coatings Co., 4 pp, ill. Technical data on Saran coatings for use where high corrosion resistance is required. (49)

Fiber Products. Spaulding Fibre Co., Inc., 16 pp. Listing of essential properties and industrial applications of fiber products. (50)

Ultrasonic Tester. Sperry Products, Inc., 8 pp, ill, No. 50-105. Industrial applications of ultrasonic non-destructive testing techniques with the portable Sperry reflectoscope. (51)

Polyvinyl Materials. B. F. Goodrich Chemical Co., 16 pp, ill. Detailed information on properties and uses of Geon polyvinyl materials in the form of extrusions, film and sheeting, coatings, molded products.

Cold Formed Fasteners. Townsend Co., 4 pp, ill, No. TL89. Discusses features, advantages and design requirements for fabricating cold headed parts and fasteners. (53)

Emulsion Cleaners. Turco Products, Inc., 10 pp, ill, 106 Series Technical Sheets. Charts, uses, methods of applications, safety precautions, etc., for seven types of emulsion cleaners. (54)

Nonferrous Castings. Universal Castings Corp., 16 pp, ill. Facilities for production of precision nonferrous castings. (55)

Other Available Literature

Irons and Steels • Parts • Forms

Precision Castings. Alloy Precision Castings Co., 8 pp, ill. Frozen mercury precision casting methods. Case histories of applications. (56)

Wire Parts and Metal Stampings. Art Wire & Stamping Co., 4 pp, ill, No. 875. Illustrates a variety of wire parts and small metal stampings that this company can produce. (57)

Welded Steel Tubing. Avon Tube Div., 11 pp, ill. Gives advantages, specifications of Fusionweld steel tubing and illustrates uses and applications. (58)

Welded Steel Tubing. Brainard Steel Co., Tubing Div., 8 pp, ill. Shows facilities for manufacturing welded steel tubing, its applications, fabrications and specifications. (59)

Steel Tubing. Bundy Tubing Corp., ill. Steel tubing for various industrial applications. (60)

Metal Stampings. Carroll Pressed Metal Co., Inc., 6 pp, ill. Features the facilities of this company for producing a complete line of metal stampings. (61)

Enameled Metal Strip. Coated Coils Corp., 4 pp, ill. Describes coiled enameled metal strip supplied in widths up to 30 in. which can be put through operations without damaging the coating. (63)

Tool Steel Selector. Crucible Steel Co. of America. Circular slide calculator enables the choice of the proper tool steel to fit the given working conditions. (64)

Forged Metal Quality. Drop Forging Assn., 6 pp, ill. Detail of several hot working processes emphasizing improvements achieved in metal structure using these processes. (65)

Centrifugal Cast Pipe. The Duraloy Co., No. 3150. Shows this company's facilities for producing centrifugal cast pipe and tubing. (66)

Steel Castings. Farrell-Cheek Steel Co., 4 pp, ill, No. 40. Examples of the intricate

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electric furnace carbon and alloy steel castings produced by this company. (67)

Stainless Steel Specifications. Peter A. Frasse & Co., Inc., chart, Sec. A, No. 2. Government specifications chart for stainless steels, including Military, Aeronautical, Navy, Army and Federal specifications. (68)

Steel Tubes. Globe Steel Tubes Co., 8 pp, ill, No. 1a/12. Specifications and tolerances of Gloweld-welded seamless tube and pipe of Globe-iron and steel. (69)

Gray Cast Iron. Gray Iron Founders' Society, Inc. Booklet gives mechanical and engineering characteristics of gray cast iron. Includes details for designing cast components. (70)

Metal Stampings. Geuder, Paeschke & Frey Co., 12 pp, ill. Detailed description of this firm's metal fabricating, finishing and assembling facilities as a subcontractor for defense parts. (71)

Stampings. HPL Mfg. Co., 4 pp, ill, No. 718. Facilities for production of stampings in small lots. (72)

Double Headed Parts. John Hassall, Inc. Catalog shows numerous double headed parts, indicating applications and suggesting other applications of double heading operations. (73)

Machine Part Castings. Hunt-Spiller Mfg. Corp., 20 pp, ill. Gun iron castings of 100% pearlitic microstructure. (74)

Permanent Magnets. Indiana Steel Products Co., 8 pp, ill, Vol. 1, No. 2. "Applied Magnetics" features two brief articles on permanent magnets. (75)

Alloy Spring Steels. International Nickel Co., Inc., 18 pp, ill, No. EZ-93/29. Reprint includes charts, tables and photomicrographs of alloy steels used for hot-formed springs. (76)

Stampings. Laminated Shim Co., Stampings Div., 12 pp, ill. Describes facilities for producing good quality stampings to specifications, facts to be considered in ordering stampings, and other data. (77)

Flanged and Dished Heads. Lukens Steel Co., 2 pp, ill, No. 606. Features stock list of a complete line of ASME and standard flanged and dished heads. (78)

Welded Assemblies. The R. C. Mahon Co., 1 p, ill. Shows several examples illustrating the capabilities of welding for construction of various assemblies. (79)

Sheet Metal Products. Maysteel Products, Inc., 10 pp, ill. Illustrates Maysteel's standard and specialized tools for producing sheet metal parts and shows some of the industries served by their products. (80)

Metal Castings. Myerstown Foundry & Machine Works, 20 pp, ill. Stock list of a complete line of ready-made Momex metal castings. (81)

Forgings. Pittsburgh Forgings Co., 8 pp, ill, No. 5201. Describes and illustrates the facilities of this company for producing drop, press and upset forgings. (82)

Metal Powder Machine Parts and Bearings. Powdercraft Corp., 4 pp, ill. Detailed specifications of a complete line of Powdercraft self-lubricating bearings and machine parts produced by powder metallurgy. (83)

Metal Containers. Pressed Steel Tank Co., 16 pp, ill. Tells how many industries have been helped in quality production at low cost by use of Hackney Metal containers and deep drawn component parts. (84)

Steel Tubing. Rochester Products Div., General Motors, 12 pp, ill, No. 271. Features typical applications of GM tubing made in both single and double walls of steel. (85)

Stainless Steel Products. Schnitzer Alloy Products Co., 64 pp, ill, No. 54. A guide and reference book covering a complete line of stainless steel products produced by this company. (86)

Centrifugal Castings. Shenango-Penn Mold Co., Centrifugal Castings Div., 6 pp, ill, No. 151. Profusely illustrates a variety of centrifugal castings of Meehanite metal Ni-Resist and special iron alloys. (87)

Spun Metal Parts. Spincraft, Inc., No. 3. Data book on metal spinning and fabricating gives data on process and help in designing for economical production. (88)

Magnet Wire. Sprague Electric Co., 4 pp, ill, No. 404. Complete data on Ceroc ST, a single-teflon, ceramic insulated high temperature magnet wire. (89)

Strip Steel, Etc. Superior Steel Corp., 12 pp, ill. Detailed data on the proper selection of Superior strip steels, stainless steels, Su-Veneer Clad Metals, alloy and spring steels, etc. (90)

Spun Metal Parts. Roland Teiner Co., Inc., ill, No. 51D. Brochure describes this company's facilities for spinning practically any metal or gage required. (91)

Precision Casting. Thompson Products, Inc., Metallurgical Products Div., 8 pp, ill, No. MP-53-1. Discusses the Intricast process of precision casting any castable metal or alloy. (92)

Steel Forgings. Titusville Forge Div., Struther Wells Corp., 8 pp, ill. Describes facilities for precision forging of parts regardless of size, metal or alloy. Shows numerous parts produced. (93)

Stainless Tubing. Trent Tube Co. "Trentweld Data Bulletin" describes Trentweld stainless steel tubing, machine formed and welded in wide range of sizes. (94)

Formed Tubing. Tube Reducing Corp., 4 pp, ill. Stresses economic advantages of hot-forming complex tubular parts in the plant in which the precision tubing is made. Describes this company's facilities. (95)

Tool and Die Steels. Uddeholm Co. of America Inc., 28 pp. A handy stock list containing a complete line of tool and die steels and specialty strip steels produced by this company. (96)

Ferro-Alloys and Metals. Vanadium Corp. of America, 24 pp, ill. "The Vancoram Review" presents technical articles on applications and developments in ferro metallurgy especially concerned with vanadium alloys. (97)

Prealloyed Steel Powders. Vanadium-Alloys Steel Co., 4 pp, ill. Discusses advantages and manufacture of prealloyed steel powders claimed to give qualities available in wrought steels. (98)

Magnetic Alloys. Westinghouse Electric Corp., 8 pp, No. TD 52-100. Complete data on a variety of magnetic alloys produced by this company includes applications and 15 core loss and magnetization curves. (99)

Screw Machine Parts and Other Metal Forms. Worthington Corp., 7 pp, No. W-350-B5C. Describes valves, flanges, hose nipples, bars, welding electrodes and screw machine products available. (100)

Mechanical Tubing. Youngstown Sheet & Tube Co., 4 pp, ill. Features size and wall thickness of a complete line of Yoloy electric weld mechanical tubing. (101)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 67 and 68

Nonferrous Metals • Parts • Forms

Aluminum Casting Alloy. Acme Aluminum Alloys Inc., 8 pp, ill. Technical data on Acme Almag 35, a light weight aluminum casting alloy combining high strength ductility and impact resistance. (102)

Die Castings. Advance Tool & Die Casting Co., 8 pp, ill. Illustrates facilities of this company to produce die castings to specifications. (103)

Aluminum Heat Exchanger Tubes. Aluminum Co. of America, 24 pp, ill, No. AD-186. Advantages, technical data, applications and specifications of Alcoa aluminum heat exchanger tubes. (104)

Aluminum Castings. Aluminum Industries Inc., 4 pp, ill, No. 20A. Describes this company's facilities offered to industrial plants that need aluminum castings for defense jobs. (105)

Quality Finished Brass. American Brass Co., 12 pp, ill, No. B-39. Complete data on Formbrite, a metal with an exceptionally fine grain structure that provides a surface superior to ordinary drawing brass, for use where the metal is to be formed or drawn into products on which finishing is an important cost factor. (106)

Bonded Metals. American Nickeloid Co., 16 pp, ill. Fabricating information and suggestions, applications and tables of properties and sizes of Nickeloid Metals. (107)

Magnesium Castings. American Radiator and Standard Sanitary Corp., 8 pp, ill, No. 377. Illustrates the facilities of this company for producing magnesium and molded castings. (108)

Precision Investment Castings. Arwood Precision Casting Corp., 16 pp, ill. Informative article on precision investment castings. Includes table of ferrous and nonferrous alloys recommended as most adaptable for this process. (109)

Nonferrous Plaster Mold Castings. Atlantic Casting & Engineering Corp., No. 4. Describes production of copper-base and aluminum alloy "Atlanticastings." (110)

Aluminum Bronze Die Castings. Aurora Metal Co., 8 pp, ill. Description, advantages and sample products of firm's vacuum die casting process. Technical details of alloys used. (111)

Precision Investment Castings. Austenal Laboratories Inc., Microcast Div., 4 pp. Offers a 7-point program covering the Microcast process of precision investment casting. (112)

Beryllium. Brush Beryllium Corp., 4 pp, ill. Uses of beryllium and its alloys and compounds. (113)

Titanium. Brush Laboratories Co., Div. of Clevite Corp., 4 pp, ill, No. 804. Complete data on titanium fabrication facilities. (114)

Bronze Bearings. Bunting Brass & Bronze Co., 64 pp, ill, No. 152. Pocket-size booklet contains complete list of industrial standard stock bearings, electric motor bearings and precision bronze bars. (115)

Standard and Special Dies. Carboloy Dept., General Electric Co., 30 pp, ill, No. D-130. Features facilities of this plant for producing Carboloy cemented carbide standard and special dies for wire, bar and tube drawing. Includes specifications. (116)

Magnesium Forms. Dow Chemical Co., Magnesium Div. Technical information on magnesium, its available forms and applications. (117)

Magnesium and Aluminum Castings. Eclipse-Pioneer Div. Foundries. "Book of Facts" shows company's facilities for custom-making aluminum and magnesium castings. (118)

Die Cast Parts. The Electric Auto-Lite Co., Die Casting Div., 16 pp, ill, No. G137. Describes facilities for economical manufacture of quality die castings. (119)

Investment Castings. Electronicast Inc., 4 pp, ill. Features specifications of the Electronicast process of centrifugal and vacuum investment casting for casting difficult alloys in intricate shapes and to extremely close tolerances. (120)

Nonferrous Tubing. Fromson Orban Co., 4 pp, ill. Lists some of the fields this company serves and the products they supply in aluminum, brass and copper tubing. (121)

Contact Rivets. Gibson Electric Co., 6 pp, ill, No. C-521. Description and specifications of a complete line of Gibson electrical contact rivets. (122)

Metal Powders. The Glidden Co., 3 pp, No. 205. Lists advantages of Resistox, oxidation resisting metal powders, and includes specification chart. (123)

Investment Castings. Gray-Syracuse, Inc., 4 pp, ill. Parts of precision cast brass, bronze, beryllium copper and steel. (124)

Copper and Brass Tubing. H & H Tube & Mfg. Co. Describes a complete line of seamless braze and lock seam copper and brass tubing. (125)

High Temperature Alloys. Haynes Stellite Div. "Haynes Alloys for High Temperature Service" provides detailed tables and charts on their properties and heat treatment. (126)

Die Castings. The Hoover Co., 12 pp, ill, No. 853. Shows this company's facilities for producing zinc and aluminum die castings. Includes design helps, describes applications. (127)

Precision Die Castings. The Jelrus Co., Inc., 4 pp, ill. Illustrates cost savings in parts production through use of nonferrous precision die casting methods. (128)

Aluminum Alloy. William F. Jobbins Inc., 12 pp, ill. Includes advantages, composition, physical properties and applications of Almag 35, an aluminum casting alloy of the aluminum magnesium types. (129)

Die Castings. Litemetal DiCast, Inc., 12 pp, ill. How to select best light metal for die casting. Shows facilities for producing light metal pressure die castings. (130)

Beryllium Copper. Manco Products Inc., 20 pp, ill. The use of cast beryllium-copper in plastic mold and zinc die cast applications. (131)

Nonferrous Die Castings. The New Jersey Zinc Co., 28 pp, ill. Applications and principal features of Zamak-3, and Zamak-5 zinc alloy die castings. (132)

Machining of Titanium. Rem-Cru Titanium Inc., 8 pp, ill, Vol. 1, No. 1. Discusses titanium machining practices and procedures recommended by customers having titanium application experience. (133)

Aluminum Extrusions. Revere Copper & Brass Inc., 28 pp, ill. Features a simplified easy-to-follow section on standard tolerances of aluminum extruded shapes, presented in table form. (135)

Tungsten Electrodes. Sylvania Electric Products Inc., 2 pp, ill, No. TC-1. Advantages, sizes, surface finishes, tempers and packing and distribution of tungsten electrodes for atomic hydrogen, helium and argon arc welding. (136)

Bearings, Bushings. Wakefield Bearing Corp., 8 pp. Booklet illustrates Graphex, Coprex and Woodex oilless and self lubricating bearings, bushings and machine parts. Also 12-page booklet listing standard sizes of bearings. (137)

Spun Tubing. Wolverine Tube Div., 28 pp, ill. Advantages and numerous applications of this firm's nonferrous Spun End Tube Process. (138)

Light Metal Forgings. Wyman-Gordon Products Corp., 4 pp, ill. Announces the availability of large-size light alloy forgings, particularly those of magnesium and 75-S aluminum. (139)

Nonmetallic Materials • Parts • Forms

Plastic Molding. Ackerman Plastic Molding Div., 4 pp, ill. Long run production of plastic parts by compression of plunger molding. (140)

Molded Plastics, Hard Rubber. American Hard Rubber Co., 80 pp, ill. Handbook of properties, tolerances and weights, design techniques, machining and finishing methods for this firm's hard rubbers and plastics. (141)

Emulsion Adhesive. American Resinous Chemical Corp., 1 p, No. A44. Technical data sheet announcing the qualities of a new emulsion adhesive for heat resistant bonds to paper, fabric, leather and other surfaces. (142)

Extruded Plastics. The Anchor Plastics Co., 8 pp, ill, No. AP51. Shows numerous applications of extruded thermoplastics and brief characteristics to aid in selection. (143)

Plastic Pipe. Carlon Products Corp., 4 pp, ill. Contains factual informative answers to most frequently asked questions about carbon flexible plastic pipe and carbon rigid pipe. (144)

Plastisol. Chemical Products Corp., 8 pp, ill. Chem-O-Sol plastisol formulation for industrial and consumer products. Instructions for use and several case histories of coated products. (145)

Plastics. Ciba Co., Inc., Plastics Div., 625 Greenwich St., New York 14, N. Y. Complete technical data on the physical properties and recommended procedures for the successful use of Araldite Resins for individual fabricating needs. Write direct to Ciba on company letterhead.

Engineered Paper Products. Cincinnati Industries Inc., 16 pp, ill. Complete data on the new double crepe Cindus material called X-Crepe that can be used like cloth, instead of rubber, in place of cork, and for jobs where no other material will do. (146)

Coated Fabrics. The Connecticut Hard Rubber Co. Uses, chemical, electrical and mechanical properties, and availability of heat resistant silicone rubber coated glass fabrics. (147)

High Temperature Insulation. Continental Coatings Corp., 8 pp, ill. Properties, typical applications and methods of applying Hylag insulation for high temperature equipment. (148)

Molded and Extruded Rubber. Continental Rubber Works, 8 pp, No. 100. Gives dimensions of molded and extruded rubber with cross sectional illustrations. Also condensed SAE and ASTM specification chart. (149)

Plastic. Crane Packing Co., 12 pp, ill, No. T-103. Complete data on Chemlon packings and gaskets fabricated from the new tetrafluoroethylene resin, Teflon. (150)

Plastics. E. I. du Pont de Nemours & Co. (Inc.), 10 pp, ill, No. 113/3. Descriptions, advantages and uses of Lucite, Polythene Nylon, Butacite, Pyralin, Plastacele and Teflon. (151)

Casting Resin. Durez Plastics & Chemicals, Inc., 16 pp, ill. Technical discussion of Durez 1421A, a phenolic casting resin in liquid form. Includes instructions for use. (152)

Laminated Thermosetting Plastics. Formica Co., 16 pp, ill, No. 314. Includes technical data on Formica, a laminated thermosetting plastic for electrical, chemical and mechanical applications. (153)

Rubber-to-Metal Adhesive. General Tire & Rubber Co., Chemical Div., 8 pp, ill, No. 4016. Complete data on Kalabond rubber-to-metal adhesive for noncorrosive solvent resistant bonding. (154)

Plastic-Faced Plywood. Georgia-Pacific Plywood & Lumber Co., 4 pp, ill. Applications, properties and description of GPX high grade exterior plywood coated with plastic. (155)

Insulating Sheet. Glastic Corp., ill. Property data and comparison charts on Glastic MM, Fiberglas reinforced laminate with high strength and heat resistance for electrical insulation. (156)

Polyvinyl Chloride Resins. B. F. Goodrich Chemical Co., 12 pp, ill, No. G-6. Describes applications of new Geon 404 resins, capable of fabrication without plasticizers by conventional methods. Includes properties. (157)

Plastic Adhesive. Goodyear Tire & Rubber Co., Inc., 24 pp, ill, No. S-9416. Properties, applications, specifications and data sheets of Pliobond, a quick-setting plastic adhesive that bonds anything to anything. (158)

Plywood. Hardwood Plywood Institute, 20 pp, ill. Physical properties of hardwood plywood; techniques for its use; and color reproductions of grain and grain structure. (160)

Structural Honeycomb for Sandwich Construction. Hexcel Products Co., 32 pp, ill, No. C. Technical data on aluminum, glass fabric, stainless steel and cotton fabric honeycomb core for sandwich construction. (161)

Plastics for Process Equipment. Johns-Manville Corp., 8 pp, ill. Technical data for insulations, refractories, transite pipe, packings and gaskets, metal raschig rings and transite sheets. (162)

Molding Powders, Etc. M. W. Kellogg Co., 20 pp. Buyer's Guide gives complete addresses of firms producing molded and fabricated materials and products made of Kel-F, a trifluorochloroethylene polymer offered by Kellogg. (163)

Acid Proof Ceramic Pipe. Maurice A. Knight, 12 pp, ill. Specifications and description of this company's ceramic pipe fittings said to be almost universally acid proof. (164)

Compression Molded Plastics. Kuhn & Jacobs Molding & Tool Co., 10 pp, ill, No. E-604. Illustrates the facilities of this company for producing compression molded plastics. Includes specifications. (165)

Fiber Glass Reinforcements. Libbey-Owens Ford Glass Co., 12 pp, ill, No. F-1. Describes company facilities and their applications, gives specifications and descriptions

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of fiber glass yarns and insulation. (167)

Natural Rubber. Linatex Corp. of America, 4 pp, ill, No. L-101. Features typical applications of Linatex, a special form of natural rubber manufactured in Malaya that is abrasion, corrosion, vibration and chemical resistant. (168)

Plastics Molding. P. R. Mallory Plastics, Inc., 4 pp, ill. Complete production facilities for large scale production of custom-molded parts from design to finishing and assembly. (169)

Hydraulic Fluid. Monsanto Chemical Co., Organic Chemicals Div., 4 pp, No. 0-D-602. Properties, test results and description of F-9 nonflammable hydraulic fluid for high-temperature uses. (170)

Carbon Products. Morganite Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings. Also properties of six series of Morganite carbon products. (171)

Mica Insulation. Mycalex Corp. of America, 24 pp, ill, No. VI. Engineering data on Mycalex, a glass-bonded mica insulation for all frequencies. (172)

Laminating Resin. Narmco Resins & Coatings Co., 4 pp, No. NRC-503. Technical data on Hi-Temp Conolon 506, a high temperature resistant laminate. (173)

Laminated Plastics. National Vulcanized Fibre Co., 16 pp, ill, No. 1b/12. Physical, electrical, mechanical and chemical properties of Phenolite laminated plastic sheet, rods, tubing and special shapes. Properties of National Vulcanized Fibre also listed. (174)

Nylon Parts. Nylon Molded Products Corp., 4 pp, ill. A simple "rule-of-thumb" method for calculating the material cost of a nylon part. (175)

Fiber Glass. Pittsburgh Plate Glass Co., 4 pp, ill. Lists advantages of using fine glass fiber mat for sound heat insulation application. (176)

Corrosion Resistant Gasketing. Products Research Co., 5 pp, ill. Features, advantages and specifications of Chromelock corrosion resistant gasketing material. (177)

Extruded and Molded Rubber Parts. Republic Rubber Div., 12 pp, ill. Describes facilities for custom manufacture of molded and extruded rubber products. Lists various products. (178)

Flexible Hose. Resistoflex Corp., 4 pp, ill. Includes chemical and physical properties and typical applications of Resistoflex flexible hose. (179)

Plastic Laminates. Richardson Co., 19 pp, ill. Complete data on laminated Insurack, including physical and chemical qualities, examples of applications in tubing, bearings, gears, sheet, etc. (180)

Cellular Rubber. The Sponge Rubber Products Co., 20 pp, ill. Properties of specifications for, and test data on this firm's cellular rubber materials. (181)

Carbon and Graphite Parts. Stackpole Carbon Co., No. 40. Shows numerous standard parts and includes helpful data on the selection of carbon-graphite products. (182)

Rubber Parts. Stalwart Rubber Co., 16 pp, ill, No. 51SR-1. Describes applications and fabrication of rubber compounds, designed to resist temperature, abrasion, chemicals and weathering. (183)

Machining Laminated Plastics. Synthane Corp., 6 pp, ill. Recommended techniques for common machining operations on laminated plastics. Includes properties and design hints. (184)

Die Castings. Tri-State Die Castings Corp. New folder describes this company's facilities for production of aluminum and zinc die castings to order. (185)

Honeycomb for Lightweight Structure. U. S. Plywood Corp., 24 pp, ill. Complete data on honeycomb "sandwich construction", a combination of honeycomb core, adhesive and two relatively thin, dense, high strength faces or skins. (186)

Synthetic Rubber Sheet and Roll Goods. Acadia Div., Western Felt Works, 2 pp, samples. Ten samples clipped to chart of physical specifications. Durometer, tensile and elongation characteristics. (187)

Finishes • Cleaning and Finishing

Metallizing Processes. Advanced Vacuum Products Inc., 2 pp, Nos. AV-55-H and AV-55-L. Technical data on the AV-55-H metallizing process for producing high temperature vacuum-tight seals, and the AV-55-L metallizing process for producing vacuum-tight ceramic seals for low temperatures. (189)

Rust Preventative. Alrose Chemical Co., 2 pp. Gives preparation and uses of Jetoil No. 1, water soluble oil for blackening ferrous metals by oxidation. (190)

Wet Blasting Machine. American Wheelabrator & Equipment Corp., 6 pp, ill, No. 33. Complete data on the Model 64 Liquamatte wet blasting machine for handling individual pieces or loads weighing up to 3500 lb. (191)

Cloth Belts. Behr-Manning Corp., 8 pp, ill, No. 726E. Folder features price list of complete line of Metalite cloth belts for polishing and grinding. (192)

Hard Facing. Cleveland Hard Facing Inc., 4 pp, ill. Service for hard facing parts subject to intense wear conditions. (193)

Spray Painting. Conforming Matrix Corp., 5 pp, ill. Gives description, uses and advantages of this firm's spraying masks, mask washing machine, and spray painting equipment. (194)

Power Driven Brushes. The Fuller Brush Co., 32 pp, ill. Describes Fullergript brushes, their application to such processes as scrubbing steel sheet and tampico brushing. (198)

New Equipment for Coating. The Gyromat Corp., 4 pp, ill. Describes Norris Gyromat, centrifugal spraying machine said to apply standard industrial coatings and finishes faster, more economically. (199)

Precision Finishing Equipment. Hollywood Bronze Supply Equipment Div., 4 pp, ill. Specifications and prices of a complete line of immersion heaters, tanks, rectifiers, assemblies, etc. for finishing. (200)

Finishing Equipment. The Murray-Way Corp. Catalog describes full line of this firm's automatic polishing, buffing and grinding equipment. (204)

Aluminum Cleaner. Northwest Chemical Co., 10 pp, ill. Attractively presents information on the Alkalume Process for preparing aluminum for spot welding. (205)

Protective Coating. Nox-Rust Chemical Corp., 4 pp, ill. Describes Nox-Rust 310-AC protective coating for metal parts. Easily applied, said to afford good protection up to 90 days. (206)

Power Brush Finishing. Osborn Mfg. Co., 12 pp, ill, No. L-272. A comprehensive article covering the important factors in the selection and application of brushes for specific finishes. (207)

Batch Blasting. Pangborn Corp., 12 pp, ill, No. 223. Dimensions and specifications of both the 6- and 12-cu-ft Blastmaster Rotoblast for batch blasting in cleaning castings, forgings and heat treated parts. (208)

Metal Finishing. Pelron Corp., 12 pp, ill. Description of metal cleaning, phosphating, paint stripping compounds and spray-booth materials. (209)

Phenolic Resin Coatings. Ric-Wil Plastic Coating & Mfg. Corp., 4 pp, ill, No. S-5252. Characteristics, chemical resistance and applications of Ricwilite 1060, a phenol resin coating (baked-on) that provides permanent protection for piping and equipment against corrosive conditions. (210)

Aluminum Coating. Royston Laboratories Inc., 2 pp, ill. Discusses Royalac Aluminum, a high quality industrial aluminum coating with the newly developed nonspattering feature. (211)

Castings and Finishing Equipment. Alexander Saunders & Co., 32 pp, ill, No. 52. Includes specifications of a complete line of castings and finishing equipment for producing fine jewelry. (212)

Cadmium Plating. The Udylite Corp., 6 pp, No. CDT-53. Technical data and description of cadmium plating process. (215)

Heat Treating • Heating

Heat Treating Furnaces. A. D. Alpine Inc., 4 pp, ill. Gives features and specifications of six Contro-Therm heat treating furnaces for all types of heat treating, soldering and brazing. (216)

Continuous Quenching Tanks. American Gas Furnace Co., 4 pp, ill, No. 820. Specifications of complete line of continuous automatic quenching tanks. Shows several factory installations. (217)

Carbonitriding. Armour & Co., Ammonia Div., 24 pp. A survey of industrial carbonitriding practice by Bever, Floe and Zaruba of M.I.T. and the Ammonia Div. of the Armour Co. Includes tables and bibliography. (218)

Electric Muffle Furnaces. Harper Electric Furnace Corp., No. 346. Features and specifications of this company's line of electric muffle furnaces for such uses as heating and annealing. (222)

Induction Heating Units. Lindberg Engineering Co., No. 1440. Descriptions and applications of this firm's induction heating units, said to give rapid, dependable operation on large or small parts. (226)

Electric Radiant Panels. Edwin L. Wiegand & Co., 6 pp, ill, No. CS605. Folder includes a variety of applications of Chromalox electric radiant panels—compact, "packaged" for infra-red generators. (230)

Welding • Joining

Screws with Integral Washer. Continental Screw Co., 6 pp, ill. Metal and plastic applications of a screw with the lock washer an integral part of screw head. (233)

Stainless Steel Fasteners. H. M. Harper Co., 56 pp, ill. Price list and stock book covering complete line of this firm's nonferrous and stainless steel fastenings. (235)

Brass and Bronze Fasteners. The Jacques Co., 26 pp, ill, No. 50. Price lists and specifications of this firm's fasteners, including various nuts, cap screws, bolts and washers. (236)

Hard Surfacing Electrodes. Lincoln Electric Co., 20 pp, ill, No. 466. The Lincoln "Weldirectory" for hard surfacing includes discussion on arc weld surfacing. (237)

Adhesives. Merchants Chemicals Co., 4 pp. Lists various Dyna Bond adhesives, their characteristics and industrial uses. (238)

Fasteners. Milford Rivet & Machine Co., 12 pp, ill, No. MM52. Detailed information on an integrated service of fastener research, design, engineering and production collaboration. (239)

Fastener. New Process Screw Co. Bulletin describes Twin-fast screws for rapid fastening of wood to metals, plastics or other woods. (240)

Materials & Methods | June, 1954

—One Point of View

The Growth of Plastics

Statistics do not tell the complete story in the case of plastics. We know that the amounts used have grown tremendously during all of the post war years. The other side of the picture is more important. Where plastics are being used gives a far better clue to the future than merely how much is used.

A visitor to the National Plastics Exposition will marvel at the industrial uses to which plastics are being put. In various forms they are used in aircraft, naval vessels, sports cars, yachts and many other places where they have had to prove themselves in competition with other well established materials. Often plastics are more expensive than previous materials, but earn the applications regardless. Perhaps this proves one important point and that is that now plastics are being chosen on their merits and not as substitutes or because of their glamour.

In addition to the end service uses of plastics parts, it is of interest to note that three of the hottest developments in industry today depend upon plastics. Three types of plastics are used in plastics tooling; two or more are being used in shell molding; several are being used in adhesive bonding and in the manufacture of sandwich materials.

We take this occasion to salute the plastics industry and to wish it continued success on the solid road to progress it now seems to be traveling.

A Birthday

Perhaps we are missing an opportunity for a big celebration. Whether or not that is true, the fact still remains that this issue marks the completion of 25 years of publication for MATERIALS & METHODS. Of course, our name has not always been that. During the first 16 years of our life, we gained the respect of the metallurgical fraternity as *Metals and Alloys.*

In looking at our first issue and comparing it with the one you now hold, it is hard to recognize a common bond. The appearance is different; those in charge are different; the scope of the articles is different. Some of these changes are in the nature of evolution. We and the rest of the industrial press have recognized that technical material need not be dull. So, in appearance we are as different as day and night.

Comparing articles we find another big difference. Once nonmetallic materials were ignored, now they are featured. Previously the highly technical was predominant, now it is the practical.

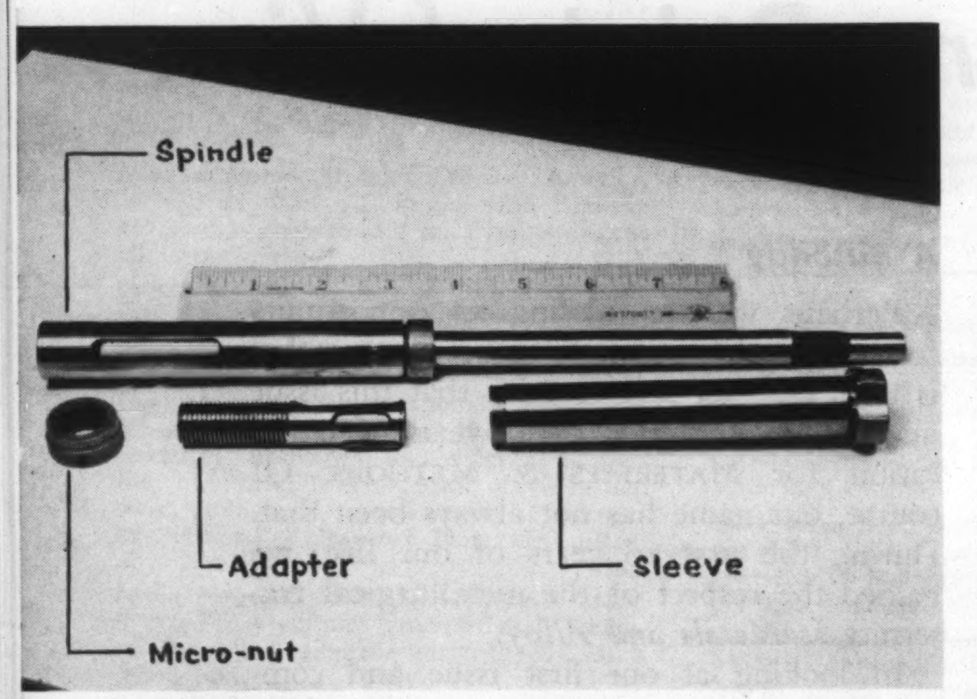
Because of these differences it might be difficult to see the thread that runs through from the first issue to the last. That common denominator is an adherence to the belief that our first duty is to our readers.

As the present editor, I want to tip my hat to my predecessors for establishing policies which have been easy to follow. I'll try to continue on that course and am sure that my successors will do likewise.

T. C. Du Mond

These Case Studies Show . . .

Improved Machinability in



SPINDLE

	AISI 4140 or 8642 (Carbide Tools)	Leaded 4140 (High Speed Tools)
Turning Operation	460 rpm 0.006-in. Feed	740 rpm 0.009-in. Feed
Drilling Operation (¾-in. dia Drill)	460 rpm 0.004-in. Feed	554 rpm 0.006-in. Feed

Machine tool: No. 3 Warner & Swasey.

Drilling operation previously had developed into a bottleneck. The deep hole (up to 3½ in.) jammed with chips and drill had to be removed frequently for cleaning. Using leaded 4140, the entire depth was drilled without removing the tool.

Threading operation was done at same speed with both steels; however, superior thread quality was obtained with the leaded steel.

Keyways were cut at same speed with both steels, but tool life increased from 4 to 7½ hr when leaded 4140 was used.

SLEEVE AND ADAPTER

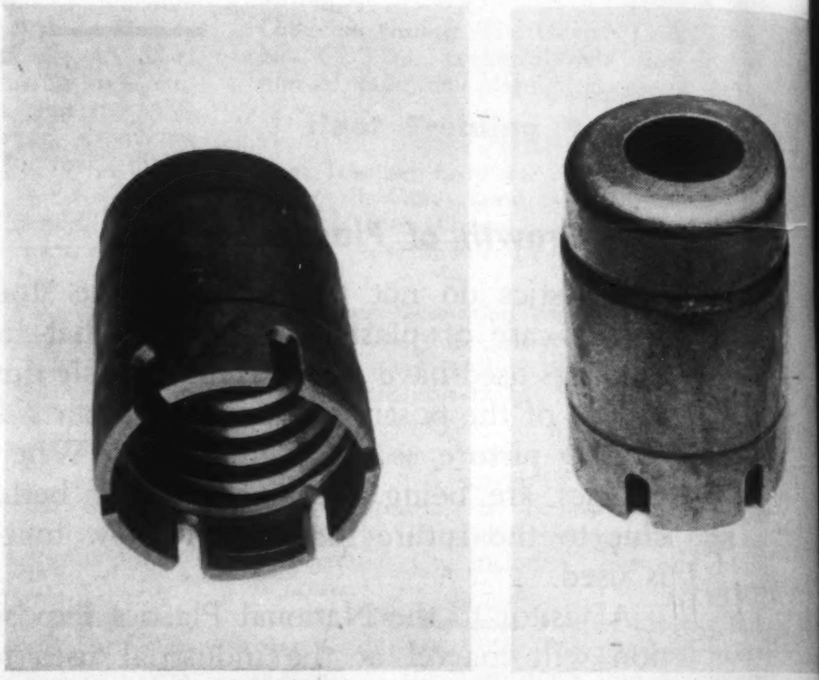
Run on same machines as spindle, and speeds and feeds are comparable.

MICRO-NUT

	AISI 4140 or 8642	Leaded 4140
Production time for one nut	90 sec	60 sec
Knurling speed (0.001-in. feed)	120 sfm	180 sfm

Machine tool: 6 Spindle 1½ in. New Britain.

All turning and drilling operations were speeded up 50% when leaded alloy steel was used.



STEEL RETAINER

RPM used on AISI 4140—104
RPM used on leaded 4140—136
Increase—31%
Pieces produced per form tool sharpening:
AISI 4140—45 pieces
Leaded 4140—65 pieces
Increase—41%

Time study data in minutes per tool:

Element	AISI 4140	Leaded 4140
Stock Stop	0.20	0.17
Drill	3.10	2.28
F. B. Drill	1.40	0.86
Form o.d. and Rough Bore	6.33	4.42
Finish Bore and Cut Off	2.03	1.19
Total Time	13.06 min	8.92 min (32% less)

A four-day run on both types of steel disclosed the following:

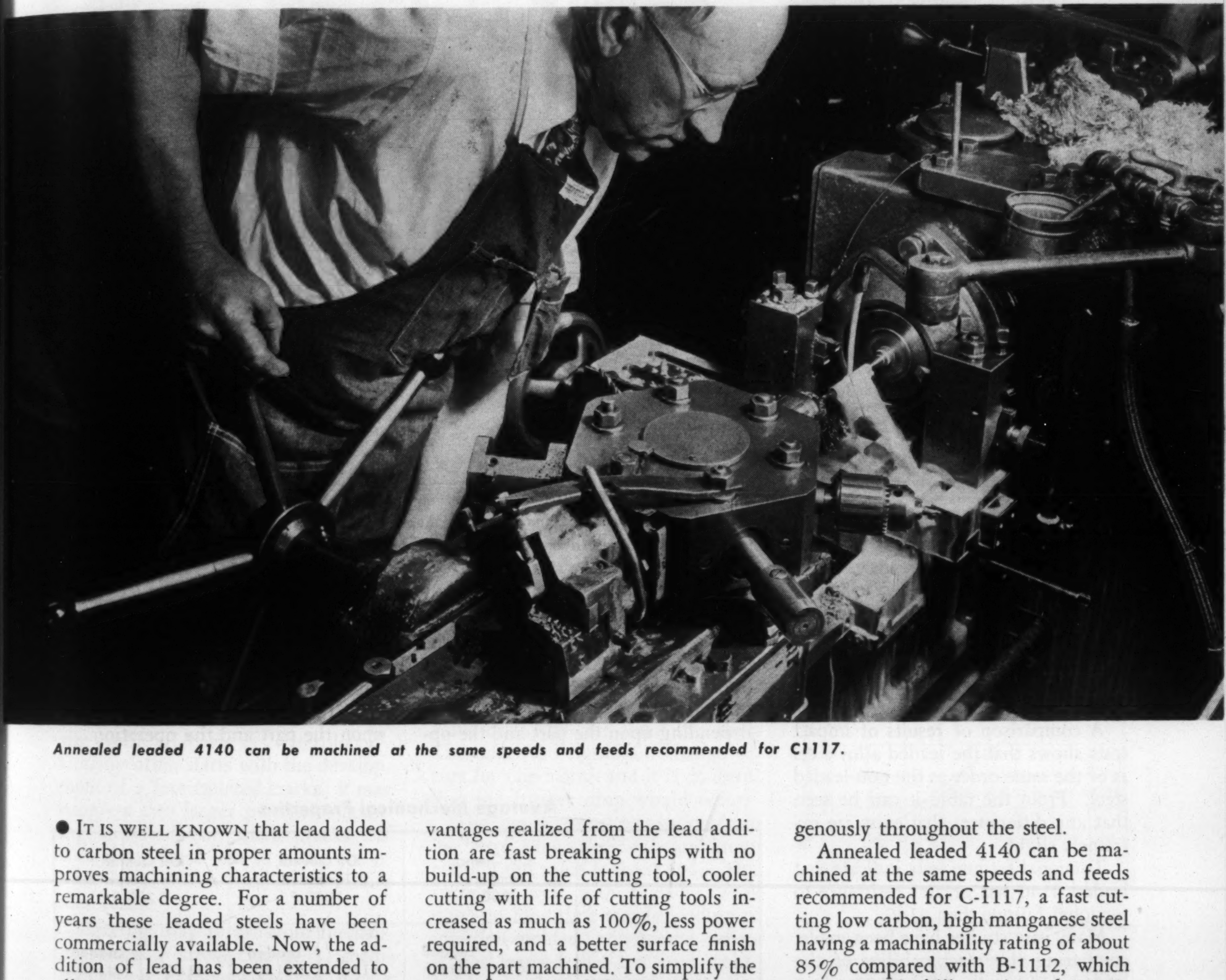
- **a** 2.75 pieces per hr from AISI 4140; this speed was maximum tooling would stand.
- **b** using leaded 4140, machine speeds were increased resulting in 4.3 pieces per hr or an increase in production of 56%.

Machine tool used: 3¾-in. Cleveland Spindle Automatic.

New Leaded Alloy Steel

Lead additions improve machinability without affecting response to heat treatment.

by W. E. FALBERG, Joseph T. Ryerson & Son, Inc.



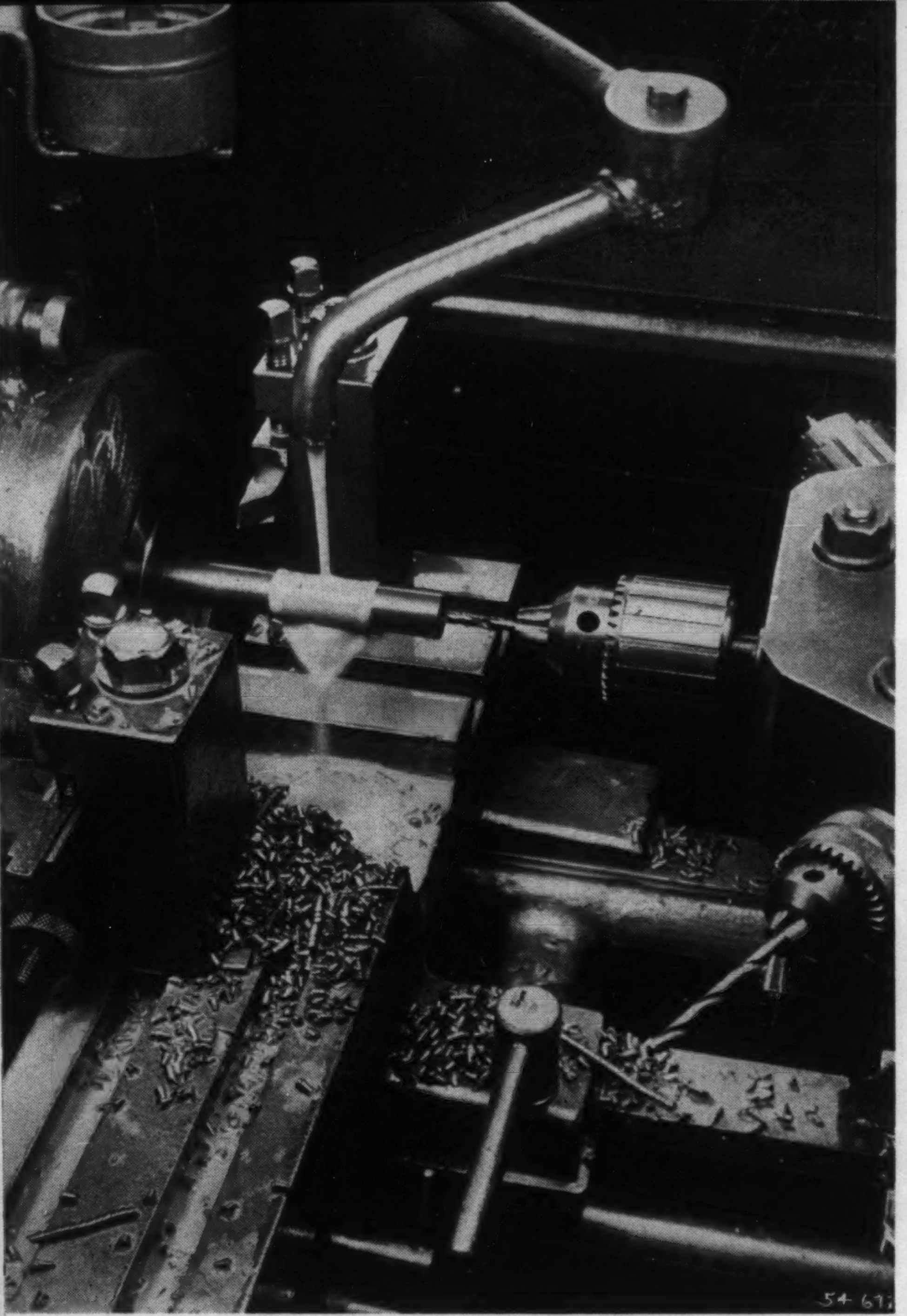
Annealed leaded 4140 can be machined at the same speeds and feeds recommended for C1117.

● IT IS WELL KNOWN that lead added to carbon steel in proper amounts improves machining characteristics to a remarkable degree. For a number of years these leaded steels have been commercially available. Now, the addition of lead has been extended to alloy steel. Such additions have resulted in 25% to 50% faster cutting speeds, with no change in the response of the steel to heat treatment. Now, leaded 4140 and 8620 are available and other grades are being developed.

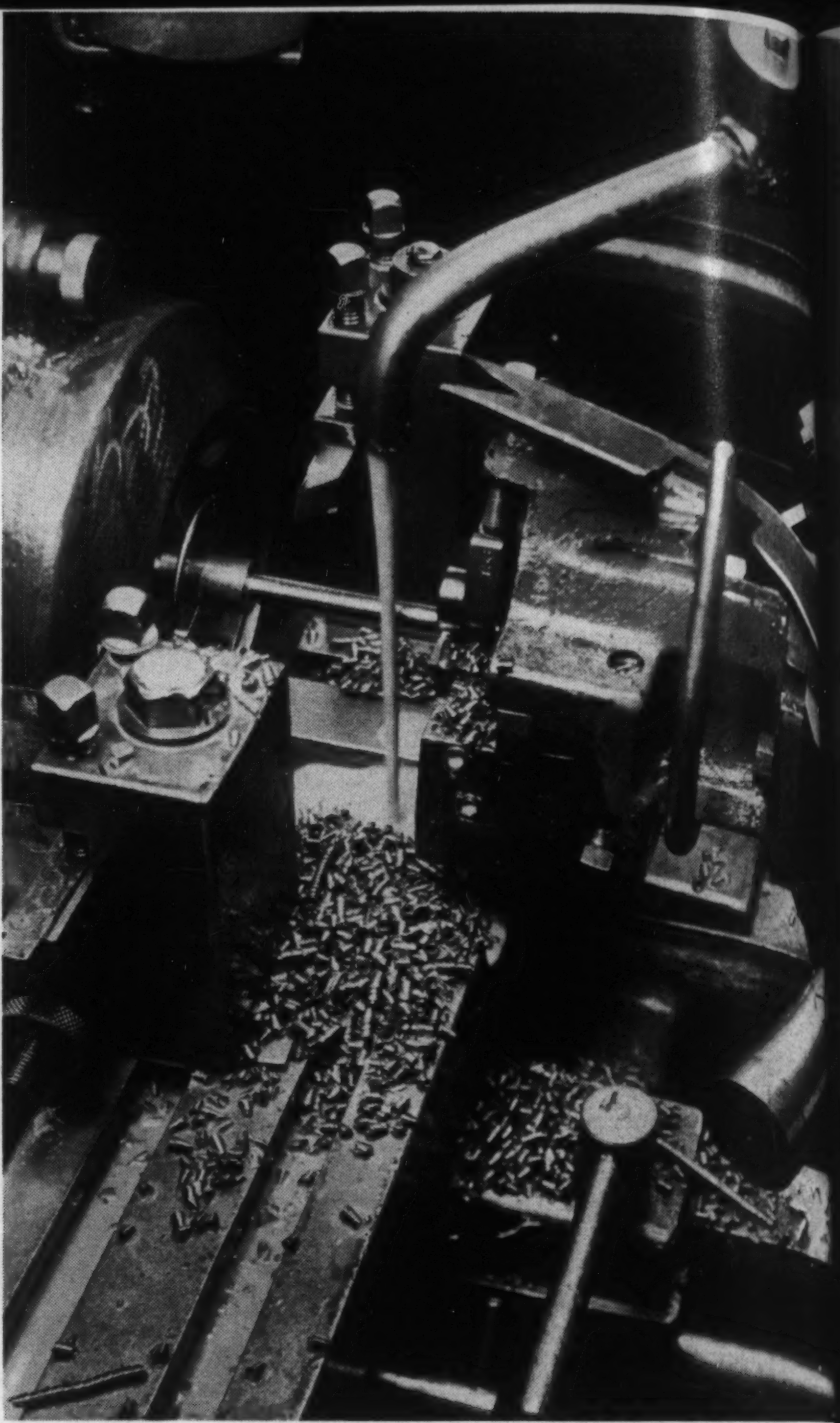
For practical purposes, the principal effect of the lead is to act as a lubricant between cutting tool and chip and the reduced friction permits higher machining speeds. Other advantages realized from the lead addition are fast breaking chips with no build-up on the cutting tool, cooler cutting with life of cutting tools increased as much as 100%, less power required, and a better surface finish on the part machined. To simplify the comparison of leaded alloy steels with steels of similar analysis not containing lead, a general purpose direct hardening leaded chromium-molybdenum 0.40% carbon steel marketed under the trade name Rycut 40 has been selected. In this steel, which is leaded AISI 4140, the lead inclusion ranges from 0.15% to 0.35%. The lead is not dissolved or combined with other elements but is distributed homogenously throughout the steel.

Annealed leaded 4140 can be machined at the same speeds and feeds recommended for C-1117, a fast cutting low carbon, high manganese steel having a machinability rating of about 85% compared with B-1112, which has a machinability rating of 100%. The heat treated leaded alloy steel machines 50% faster than a heat treated alloy steel of comparable analysis without lead.

As previously stated, leaded 4140 responds to heat treatment in the same manner as non-leaded AISI 4140. A study of the mechanical properties of these two steels shows that when they are heat treated in various hardness



For practical purposes, the principal effect of lead is to act as a lubricant between cutting tool and chip.



Spindle for ball bearing hand piece for burring tools being machined from leaded 4140 steel.

ranges, the properties are of the same order. Of particular significance is the fact that the leaded steel is more ductile as measured by elongation and reduction of area.

A comparison of results of impact tests shows that the leaded alloy steel is of the same order as the non-leaded steel. From the table it can be seen that any differences that exist are extremely slight.

Torsional fatigue tests indicate that leaded 4140 has greater resistance to torsional fatigue than 4140.

Many case studies have been made, comparing the machinability of the leaded 4140 with AISI 4140. Two representative examples of the increased production that can be secured with the leaded alloy steel are illustrated. Of course, results may vary from one shop to another, depending upon the condition of the machine tool and the cutting tools, the experience and skill of the operator, and other factors.

However, the following improvements can be anticipated:

Machinability—The standard rate of machining AISI 4140 is 105 S.F.M. while leaded 4140 has been machined at 135 to 195 S. F. M., depending upon the part and the operation being performed (figures based on high speed steel tooling).

Tool Life—Tool life when machining leaded 4140 increased from 25% to as much as 400%, depending upon the part and the operation.

Average Mechanical Properties

	Oil Quench, Tempered 800 F		Oil Quench, Tempered 1000 F		Oil Quench, Tempered 1200 F	
	4140	Leaded 4140	4140	Leaded 4140	4140	Leaded 4140
Tensile strength, psi	204,000	202,000	170,000	166,000	131,000	129,000
Yield point, psi	194,000	190,000	159,000	155,000	115,000	113,000
Reduction of area—%	45	46	52	54	61	62
Elongation—2 in.—%	12	12.5	16	16.4	20	21
*Impact—ft. lb.	21/23	21/23	—	—	44/45	42/43

* *Charpy Keyhole.*

Picture Credits: Franklin Belmar Corp.

Crazing in Polystyrene Parts

by **E. E. ZIEGLER,** Plastics Technical Service, Dow Chemical Co.

Failures and poor appearance caused by familiar cracking phenomenon can be eliminated by realistic design strengths. Here is concrete data showing how allowable design strengths vary with many different service conditions and environments.

● THE "CRAZING" OF plastic parts is a familiar phenomenon. Much consumer dissatisfaction with plastic products has been caused by visual unattractiveness and, in many cases, mechanical failure resulting from crazing. This article describes briefly the results of a recent test program designed to eliminate some of the unknowns in the crazing of polystyrene in particular. Its purpose is to provide information that will aid in the intelligent selection of plastics materials for specific end uses and in the design of parts to function more satisfactorily over long periods of time under adverse conditions.

"Crazing" may be defined as fine cracks on or under the surface of a plastic. These cracks may range from those of relatively large size, individually visible to the unaided eye, down to those of almost microscopic size visible en masse as "waterbloom". Crazing often starts with the development of a few isolated cracks; it may progress into larger patterns containing hundreds of small cracks. If enough of these join to create one or more large cracks, mechanical failure may result.

Crazing may result from mechanical stress ("stress crazing"), chemical action ("solvent crazing") or a combination. Mechanical stresses may result from externally applied loads, they may be induced by localized overheating or thermal shock, or they may be set up in molding by forced molecular orientation, packing or differential cooling. In solvent crazing, the critical elongation is lowered by the chemical action of one of a wide variety of reagents.

Crazing is believed to result from localized elongations of greater magnitude than the material can accept. Here the term "critical elongation" will be used to mean that elongation at which, under a particular set of conditions, crazing is known to start. Values of critical elongation or strain can be translated into terms of stress, or vice versa, by means of the stress-strain curve for regular polystyrene shown in Fig 1.

Time

The time dependence of unoriented compression-molded polystyrene held at constant strain is illustrated in Fig 2. The material was tested at 75 F in air and water. As the graph shows, polystyrene has an instantaneous (30 sec) critical elongation of 0.78%. This is reduced by about 50% in 5 hr and does not reach an equilibrium value of 0.32% for about two days. Thereafter, no significant change occurs for one month and it is doubtful that any further drop would occur.

The loss in critical elongation from its "zero" time value to the minimum equilibrium value is about 60%. This correlates well with previous work done on long time tensile loading of injection-molded polystyrene where it was learned that test bars would hold only about 40% of their rated ultimate tensile strength in long-time constant load tests.

These data emphasize the need for a large safety factor in the design of polystyrene moldings involved in tensile loading. They also indicate the need for more complete, more realistic, values of tensile strength for plastics. Actually, a polystyrene molding cannot withstand the quoted ultimate tensile stress of 6500 psi for more than a few seconds without breaking. As the above data shows, unoriented polystyrene cannot withstand more than about 1500 psi for an indefinite period. Subsequent data will show it cannot withstand even that stress at temperatures above 75 F or in contact with reagents other than air or water.

Although it is generally agreed that crazing is the beginning of failure in plastic moldings, its significance is not necessarily the same in applications involving constant strain as in those involving constant load. It has been shown that, for a given stress, craze penetration increases linearly with time. In constant load applications, therefore, unit stress becomes progressively greater on the unruptured area. Obviously it is of utmost importance in constant load applications to prevent crazing from starting, since the inevitable result of even minor crazing is eventual mechanical fracture of the molding. In the case of constant strain, however, the occurrence of a few craze cracks may well mean that the "weak links" in the molding have been broken, that the

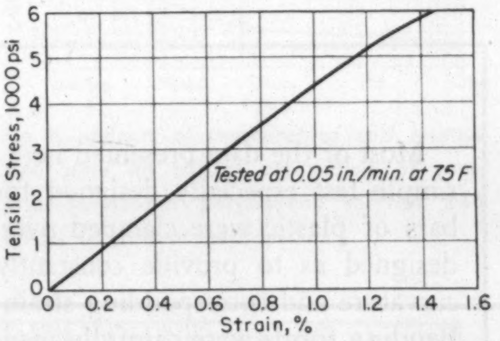


Fig 1—Stress-strain curve for polystyrene.

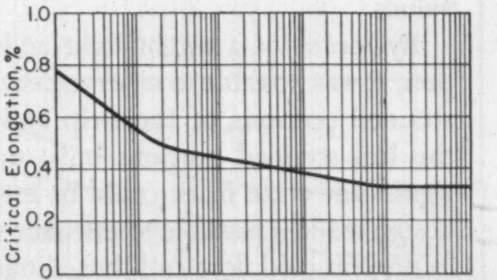


Fig 2—Effect of immersion time alone on critical elongation of un-oriented compression-molded polystyrene (Styron 666 Clear).

remaining stronger portion can accept the elongation involved, and that, by virtue of some creep or cold flow, the actual stress becomes progressively lower. Under these conditions the molding retains its visual appearance and mechanical strength without further change.

Temperature

The variation of polystyrene's critical elongation in air or water over a wide temperature range is shown in Fig 3. Above the freezing point of water, the time required to reach minimum elongation is inversely proportional to the temperature. The critical elongation would probably continue to drop with increase in temperature up to the point at which the material begins to soften and its ultimate elongation rises. Above this temperature critical elongation has no practical significance.

Light

Although long-time data are not yet available, short-time exposure tests of polystyrene have been conducted and the results are given in Table 1. The data show that exposure to various light sources has an appreciable effect on the critical elongation of polystyrene. Prolonged heating in the absence of light seems to do little harm as long as stress is not applied to the molding until it cools. As the wavelength of light decreases and as accompanying temperature increases, the adverse effect on critical elongation becomes more pronounced. This helps explain why polystyrene and other plastic moldings craze so markedly during exposure in Arizona.

Reagents

The time-crazing behavior of polystyrene in air and water has already been discussed. As indicated by Fig 4, the time-crazing effects of other environments on polystyrene vary widely according to the nature of the reagent. Methanol, for instance, takes only a few minutes to reduce polystyrene's critical elongation to its minimum of 0.23%, corresponding to a stress of about 1000 psi. Propylene glycol, on the other hand, takes at least 150 hr to reduce the critical elongation to a minimum of 0.18% corresponding to a stress of about 800 psi. Immersion at temperatures above 75 F would depress these values still further. Even fingerprints on a stressed surface depress critical elongation to 0.35% in 30 sec and as low as 0.11% (500 psi) in some long-time tests.

Kerosene—Usefulness of kerosene in determining stress levels in molded polystyrene parts has been debated for years. Fig 5 shows the effect of high and low grades of kerosene

Table 1—Effect of Various Exposure Conditions on Polystyrene*

Exposure	Time, Hr.	Critical Elongation, % (30 sec)
None	0	0.78
Dark oven at 170 F	850	0.72
Fluorescent light (standard white)	850	0.77
"Black light"	850	0.70
Weatherometer	100 200 450	0.78 0.73 0.68
Fadeometer	100 200 450	0.76 0.70 0.66
Germicidal light	200 450	0.51 0.45
G. E. Sunlamp at 140 F	200 450	0.45 0.33

* *Styron 666 at 75 F.*

A New Crazing Test

Most of the data presented here were obtained from a simple test especially designed for this program. Test bars of plastic were clamped over "bending forms" so designed as to provide constantly changing radius of curvature and corresponding strain in the test specimen. Bending forms were carefully made to conform to three different curves providing a wide range of elongation values.

By means of a bright light and close visual examination, it was possible to observe heavy crazing in the highly strained portions of the strip and to follow it out into the less strained portions until the location of the last significant craze mark could be established. This simple design made it possible to calculate elongations accurately, to prevent cold flow and thus eliminate it as a factor, and to transport or immerse the apparatus as needed. Critcial elongations determined by this method correlated well with values obtained with a less convenient universal testing machine.

Specimens used in the test were $\frac{1}{8}$-in. compression-molded bars. Injection molded specimens are hard to make in quantity with internal stresses uniform enough to allow an accurate determination of critical elongation under a variety of conditions. Compression-molded specimens, on the other hand, are quickly and easily made in quantity with uniformly low internal stress. They need no careful machining or annealing and no account need be taken of the direction of plastic flow. Moreover, critical elongation values on compression moldings correlate well with those obtained on injection moldings tested "across grain". This, plus the fact that these critical elongation values are known to be practically the lowest obtainable, means they can be translated directly into useful values of tensile stress below which even the weakest part of the molding will perform satisfactorily but above which it may craze.

Table 2—Effect of Dairy Products and Constituents on Polystyrene*

Reagent	Critical Elongation, %	
	30 Sec.	Long-Time
Water	0.78	0.33
Lactic Acid	0.69	0.19
Skim Milk	0.64	0.17
Homogenized Milk	0.44	0.14
Condensed Milk	0.34	0.12
Cream	0.29	0.10
Butter	0.29	0.10

* *Styron 666 at 75 F.*

obtained from various sources in the United States. The wide variation in "instantaneous" values of critical elongation appears to substantiate objections to the use of kerosene on the basis that no two kerosenes are exactly alike and that results, therefore, are not reproducible. Long-time values, however, cover a much narrower range, indicating that use of kerosene for crazing tests could be justified if testing time is sufficient and other petroleum fractions such as "range oil", "heater oil" or "distillate" are not substituted for kerosene. The long-time values indicate that polystyrene moldings craze in contact with kerosenes when stressed above 200 psi.

Normal Heptane—Recently there has been rather wide acceptance of normal heptane immersion as a "cure-all" test for polystyrene moldings. Its users have immersed moldings ranging in weight from a few ounces up to several pounds at or near "room" temperature for times varying between a few seconds and 30 min., in most cases without knowledge of the exact effect of such immersion. Fig 6 shows the effect of pure normal heptane on polystyrene at three temperatures. Normal heptane is so effective in lowering polystyrene's critical elongation that, at 90 F, stresses above 50 psi will cause crazing. However, the importance of temperature and time of immersion is evident.

Laboratory tests have shown that normal heptane is not easily removed from a polystyrene surface. Apparently the penetration of a small amount into the molding continues to depress the critcial elongation long after evaporation has removed the surface excess. Normal heptane is still retained internally after one week's "drying" time at 75 F and 50% relative humidity. All these facts indicate that testing of polystyrene parts in normal heptane should be undertaken only after the operational details and significance of the test are thoroughly understood and, preferably, only after correlation with actual end use has been established.

Dairy Products — The effects of dairy products and constituents are shown by the data in Table 2. It is clear that the relatively short life of average polystyrene tumblers used regularly with milk products is due more to the effect of butterfat than to that of lactic acid. Thermal stresses are set up in a polystyrene tumbler when cold milk is poured into it. The table (with Fig 1) shows that if stresses in tumblers used for some time with milk were over 450 to 600 psi at 75 F crazing would occur. Normally, a thin layer of milk remains on the inside walls of a tumbler when it is washed. At 125 F (hot dishwater), the critical stress would be down to about 300 psi. In scalding rinse water a stress of about 200 psi would be enough to start

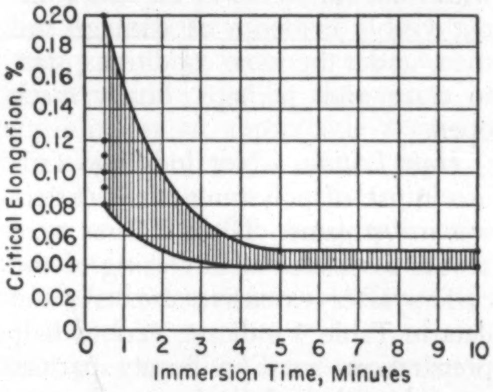


Fig 5—Effect of immersion time on the range of critical elongation values for polystyrene in high and low grades of kerosene obtained from various sources in the United States.

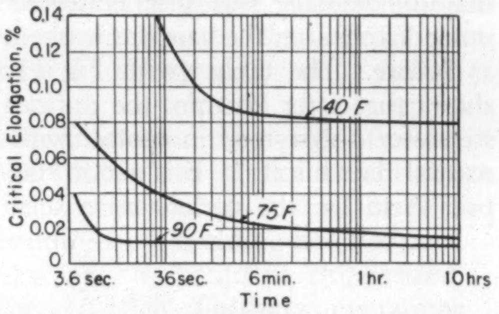


Fig 6—Effects of temperature and immersion time on critical elongation of compression-molded polystyrene (Styron 666 Clear) in normal heptane.

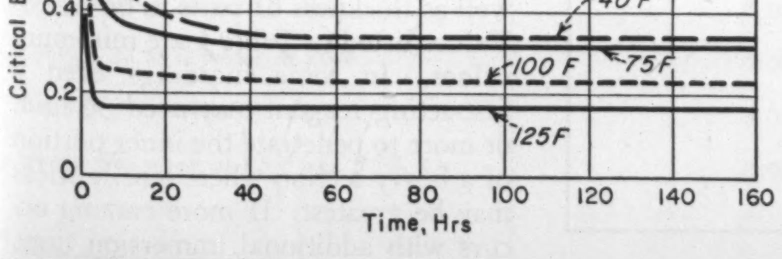


Fig 3—Effects of temperature and immersion time on critical elongation of polystyrene (Styron 666 Clear) in air and water.

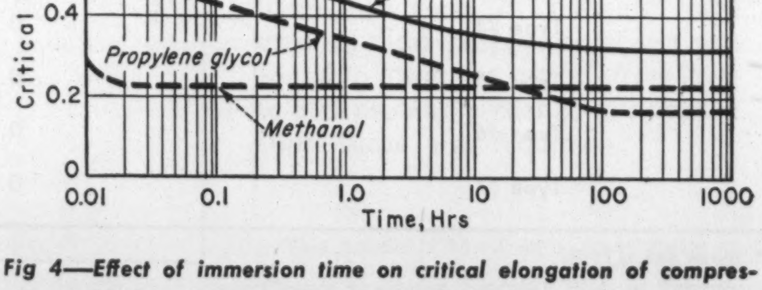


Fig 4—Effect of immersion time on critical elongation of compression-molded polystyrene (Styron 666 Clear) in water and two reagents at 75 F.

crazing. A good portion of this stress could be created by thermal shock caused by the hot rinse itself, leaving little margin to accommodate internal molding stresses or mechanical loading stresses.

It has been found that the effect of milk products on polystyrene is cumulative. The critical elongation is the same whether the molding is immersed in stressed condition for a given time or immersed in totally unstressed condition, washed in soapy water, dried for 24 hr and then stressed for the same time interval. Apparently there is some penetration even by relatively viscous fats and oils which makes removal by surface washing practically impossible. It is easy to see why tumblers can be used with milk for weeks or months without visible evidence of damage and then, under the same conditions, start to craze and, perhaps, finally crack open.

Hair Lotions—Not long ago failure in use of polystyrene hair curlers was investigated. These failures were always associated with crazing of the curlers after extensive use. As the data in Table 3 indicate, various hair preparations used in beauty parlors proved to be relatively harmless to polystyrene. It was then discovered that natural hair oil lowered the critical elongation much more severely than any of the prepared lotions, and that the damage was just as severe immediately after the hair was washed as before. The table (with Fig 1) shows that after 20 min. the critical stress for polystyrene in contact with natural hair oil at 75 F is about 700 psi. Actually, the curlers were subject to temperatures as high as 185 F and considerable mechanical stress was involved. A chemically resistant plastic formulation with high heat distortion and three times as high a critical elongation is now being used in this application.

Table 3—Effect of Hair Lotions on Polystyrene*

Reagent	Critical Elongation, %	
	30 Sec.	20 Min.
Air or Water	0.78	0.48
Type A Cold Wave	0.82	0.45
Type B Cold Wave	0.75	0.43
Type C Cold Wave	0.74	0.37
Cream Fixative	0.72	0.34
Powdered Bleach Solution	0.71	0.33
Lanolin Wave	0.69	0.39
Natural Hair Oil	0.24	0.15

* *Styron 666 at 75 F.*

Wall Tile Cleaners—Many crazing problems associated with polystyrene wall tile have been traced to the use of various tile "cleaners" for removing excess mastic and imparting a polished (and sometimes destaticized) finish. The data in Table 4 show the wide variation in the effect seven commercially available cleaners have in just 30 sec of application time.

Table 4—Effect of Wall Tile Cleaners on Polystyrene*

Cleaner	Critical Elongation, % (30 sec.)
Air or Water	0.78
Type #1	0.34
Type #2	0.28
Type #3	0.26
Type #4	0.21
Type #5	0.16
Type #6	0.15
Type #7	0.06

* *Styron 666 at 75 F.*

Internal Stresses

The information developed on the effect of various reagents on critical stresses in polystyrene can be used to determine internal stress levels in moldings. More specifically, if the moldings are immersed at constant temperature and for sufficient time in a series of reagents for each of which the corresponding minimum critical stress is known, the magnitude and location of internal stresses can be determined by observing in which reagents and in what areas the moldings craze. The data contained in Table 5, although far from complete, indicate what may be done in cataloging the effects of reagents on polystyrene in descending order of critical elongation or stress.

Use of the information in Table 5 is not as simple as it might appear. It is necessary to study the problem thoroughly, to understand the fundamentals of polystyrene's crazing behavior and to appreciate the effect of contributing variables. The following points should be considered before undertaking test work:

1. The acceptable internal stress level should be decided ahead of time, preferably on the basis of actual use tests.
2. Moldings must not be tested while still warm, i.e., directly out of the molding machine, but allowed to reach equilibrium before they are immersed.
3. Time of immersion necessary varies with type of stress involved as well as thickness of parts to be tested. Values listed in Table 5 are minimum values. In some moldings even a fast-acting reagent may need 30 min. or more to penetrate the inner portion of a heavy section where tensile stress may be greatest. If more crazing occurs with additional immersion time,

the plastic part has not reached equilibrium and a final decision on exact stress level cannot be made.

4. Parts immersed in test reagents are permanently damaged and should be destroyed. The same part cannot be used for immersion in more than one type and strength of solution.

5. No two moldings are ever exactly alike as far as internal stresses are concerned. The average of several trials should be used.

Other Crazing Data

Crazing cracks tend to disappear or "heal" with time after removal of stress when moldings are stored at some elevated temperature. For example, internal and external crazing in injection- and compression-molded test bars crazed in air, methanol and in normal heptane did not heal visibly in 1000 hr at 75 F. At 170 F, however, the visible healing that occurred within 100 hr was noticeable and within 600 hr was nearly complete. Little or no mechanical strength was regained. Repeated and prolonged compressive stress on previously crazed moldings is also effective in visual healing but ineffective in restoring original mechanical strength.

Table 5—Effect of Test Reagents on Polystyrene

Reagent	Minimum Equilibrium		
	Critical Elongation, %	Critical Stress, Psi	Effective Speed
Air or water	0.33	1500	Very slow
Isopropyl alcohol	0.28	1250	Fast
Methanol or ethyl alcohol	0.23	1000	Fast
Lactic acid	0.20	900	Very slow
10% Normal heptane, 90% isopropyl alcohol	0.18	800	Fast
15% Normal heptane, 85% isopropyl alcohol	0.16	700	Fast
20% Normal heptane, 80% isopropyl alcohol	0.13	600	Fast
25% Normal heptane, 75% isopropyl alcohol	0.11+	500	Fast
30% Normal heptane, 70% isopropyl alcohol	0.10	450	Fast
40% Normal heptane, 60% isopropyl alcohol	0.07+	350	Fast
50% Normal heptane, 50% isopropyl alcohol	0.06	300	Fast
60% Normal heptane, 40% isopropyl alcohol	0.05	250	Fast
70% Normal heptane, 30% isopropyl alcohol	0.04	200	Fast
85% Normal heptane, 15% isopropyl alcohol	0.03	150	Fast
95% Normal heptane, 5% isopropyl alcohol	0.02	100	Fast
Normal heptane	0.01+	50	Fast
Petroleum ether	0.01−	<50	Fast

Table 6—Effect of Crazing on Electrical Properties of Polystyrene*

Condition of Specimen	Dissipation Factor at 10⁶ Cycles
As molded	0.0001
Crazed (while stressed) in normal heptane	0.0006
Stored one week at 75 F and 50% R.H.	0.0006
Dried in oven 24 hr at 150 F	0.0001
Soaked 24 hr in water at 75 F	0.0007
Dried in oven 24 hr at 150 F	0.0001
Stored one week at 75 F and 50% R.H.	0.0001

* *Styron 666 Clear at 75 F.*

Exposure of similar moldings at a temperature just above the second order transition point, i.e. 185 F, resulted in visible healing within 24 hr. In many cases the visible healing was complete within 100 hr and was accompanied by an appreciable regain of mechanical strength. Since exposure of most moldings of regular polystyrene at 185 F for any length of time results in objectionable deformation, this treatment is relatively impractical.

Data presented in Table 6 show that crazing does not adversely affect the electrical properties of polystyrene, provided there are no entrapped contaminants.

This article has emphasized the importance of proper understanding and application of the concept of "critical elongation" or "critical stress" in the selection of polystyrene formulations and the design of moldings for various service conditions. The importance of internal stresses resulting from molding has also been discussed. It should be emphasized, however, that finishing operations often performed on polystyrene moldings also have an important effect on crazing behavior. Machining or buffing may cause localized overheating with resultant mechanical stresses. Excessive fastening pressures may also set up mechanical stresses. Solvent crazing may be caused by the wrong liquid coolant, the wrong buffing compound, the wrong lacquer or the wrong adhesive. Even a protective covering may sometimes do more harm than good. A "masking" tape used on clear polystyrene sheets was found to lower the critical stress level to 500 psi, and a change in adhesive formulation was required.

This article is based on a paper delivered at the 10th Annual Meeting of the Society of Plastics Engineers, February 1954, in Toronto.

The author, right, points out a detail on one of the castings discussed in the article. To his right is an assembled N1 carrier unit with chassis consisting of three aluminum die castings.

Aluminum Die Castings in Telephone Equipment

Economic, engineering, and production factors must all be considered before choosing between die castings and fabrication. Here is why aluminum die castings proved practical for a limited production item.

by **L. PEDERSON**, Transmission Systems Development, Bell Telephone Laboratories

● MANY QUESTIONS usually confront the design engineer when he attempts to decide between the use of die-castings and fabricated structures. The all-important question of cost is primarily one of comparison—that is, what will be the unit cost of a die-casting versus a fabricated structure? A demand for a large number of units is not necessarily the criterion for justifying a die-casting economically; complexity of design is an equally important factor. A simple shape that can be punched or extruded would not, as a rule, be a good candidate for the die-casting technique. Or, particularly for low-demand items, it may sometimes prove advisable to use another method, such as sand or permanent-mold casting. As a rough guide to the designer, however, it can be stated that an item of fair complexity with an annual demand of around 5000 probably justifies die-casting.

A characteristic of die-casting is that the die cost is relatively high, but the unit cost is low. In deciding on a production method, consideration must also be given to other factors besides cost, such as strength, uniformity and appearance. The uniformity of die-castings shows to great advantage on the assembly line of high production equipment. The time-consuming annoyances of misalignments and necessary adjustments usually present with fabricated parts are nonexistent with properly designed castings.

A recent project in which die-castings have had an important part is the N1 carrier telephone system. In this system the size and weight of the equipment have been minimized by arranging miniaturized components compactly in die-cast aluminum frames. These are of a size and shape to best utilize the rack space available in depth as well as in breadth and height. In this type of design, usually referred to as "cubic" construction, as contrasting with "planar" construction of conventional panels, the engineer benefits from the use of die-castings, since the various mounting surfaces, as well as pockets or compartments for a variety of components, are easily formed by the die-casting process.

Design Considerations

In evaluating some of the experiences gained during the design period of the N1 carrier equipment, it is interesting to note that Lesson No. 1 for the design engineer is to "think" die-casting. This ability comes only with experience and is absolutely necessary to take the best advantage of the die-casting art. The designer should be able to build into the casting the many possible advantageous features, and the art provides him with wide latitude to accomplish this objective. In the early design stages, close cooperation between the design engineer and die designer is a must.

Another lesson is the fact that unnecessary accuracy means added tool expense. It is good engineering to limit the use of close tolerances to the really important dimensions. Also, the design engineer must dimension from a common reference, rather than build one dimension upon another. The minimum tolerances specified for the N1 carrier die-castings were held to ±0.004 in. on any dimension, although ±0.002 is a tolerance common in die-casting practice.

When specifying wall thickness, it is good practice to use thin walls and obtain required strength by using ribs. There is, of course, a practical minimum to the wall thickness. One governing factor is the necessity of filling the die properly. The minimum wall thickness specified for the N1 system castings is 7/64 in. However, it is wise to remember that each design should be treated as an individual problem. This applies equally to consideration of size and weight of a casting, tapers and hole diameters. Taper should be treated with considerable respect, since it is something the die designer evidently never gets enough of. Taper or draft refers to the slope of the walls of sections and sides of holes, which facilitates withdrawing the casting from the die without tearing, sticking or distorting the part.

Machining of castings, where required, is usually limited to drilling holes too small to be cored economically (less than 1/8-in. dia), tapping and squaring surfaces where taper required in casting cannot be tolerated. A machining operation may also be indicated where the dimensional accuracy required is such that it cannot readily be provided by the die.

Castings require removal of excess metal. The usual way of removing the excess, or flash, is by shearing in a punch press. For large demand items, special jigs are constructed for this purpose. In a number of instances hand filing serves the purpose.

Material Choice

Aluminum was chosen for the N1 application because of its light weight (approximately 40% of that of zinc die-castings), low cost, dimensional stability, good electrical shielding properties in the carrier frequency range, and the practical nature and rather pleasing appearance of the natural aluminum finish. The aluminum alloy that is used in this process contains 87.5 aluminum, 9 silicon, and 3.5% copper. It has a tensile strength of 40,000 psi, a yield strength of 25,000 psi, and an impact strength of 3 ft-lb.

Aluminum alloys form and maintain a thin transparent oxide surface film which, for many uses, is sufficient protection for the part, and no further finishing is necessary. This is an important item when cost is a design consideration. A variety of finishes, however, may be applied. These may be organic, electrolytic oxide, electroplating, chemical or mechanical treatments. One rather effective low-cost finish is a light sand blasting followed by a mineral oil dip, which does not leave the surface noticeably oily, but prevents fingerprints from smudging the surfaces.

Dies

Some dies, such as those used for the N1 carrier castings, can be employed for several castings simply by changing one or more of the movable cores or slides. The die illustrated is such a combination die, having two slides available for producing two different front surfaces, leaving all other parts of the die the same. Obviously, this feature reduces tool costs an appreciable amount. The tooling interval that was involved for this rather complex die was fourteen

Casting Machines

There are two basic classifications of die-casting machines in use today: (1) the "submerged-plunger" type used for casting tin, lead, and zinc; and (2) the "cold-chamber" machine, used for aluminum, magnesium and copper. The aluminum alloy castings for the N1 carrier are produced on a "cold-chamber" machine. This type of machine requires that prior to each casting the molten metal be ladled, either manually or automatically, into the injection cylinder. From there it is forced into the die by a hydraulically operated plunger. In the "submerged-plunger" type machine, the plunger and cylinder are submerged in the molten metal in the furnace. At the end of each "shot," metal flows into the cylinder, and, at the start of the next cycle, it is forced by the plunger into the die. Because of the likelihood of contamination by the steel or cast iron of the plunger and cylinder, high melting point alloys, such as those used for the N1 carrier castings, cannot be used in submerged-plunger machines.

The metal pressure used for the castings shown in Fig 2 starts at 4500 psi and reaches a peak of 9000 psi. The production rate of casting machines varies with a number of factors such as size and complexity of the casting. The pictured castings are produced at a maximum rate of 75 to 77 per hr.

weeks.

Design changes affecting the completed die are not desirable, and if made are usually risky as well as expensive, since the die may be distorted to the extent that an entirely new die must be made.

Since the greatest percentage of die cost is labor, it is important that the die steel be adaptable to machine processes. Fully annealed high quality steel is usually used, with full heat treatment following the completion of the die. From here on, there are a number of problems such as heat treating characteristics, heat checking, cracking, distortion, and resistance to deformation, which are the concern of the die designer and are not within the scope of this article.

The total number of castings that may be produced from one die depends upon the type of castings. The dies for the N1 castings are expected to produce up to 200,000 castings.

In the case of the N1 carrier development, the problem of producing eleven different die-castings, with a relatively high tool cost for each, required rather careful planning. In view of the fact that the project in general contained many novel features, possible changes in design might well have been expected even after the equipment was in production. If such changes affected the dies, fabrication might have been less expensive than die-casting until the design was more stable. The annual demand for the N1 carrier equipment was estimated in the early design stages to be 1000 systems a year (actual production is now 1200 systems a year), each completed system requiring from two to as high as 24 castings of one kind. On this basis, and assuming only minor casting changes, it was found that the savings obtained through the use of die-castings would justify complete retooling after completion of the first 100 systems. Thus, cost dictated the use of die-castings from the start of production of the N1 carrier units.

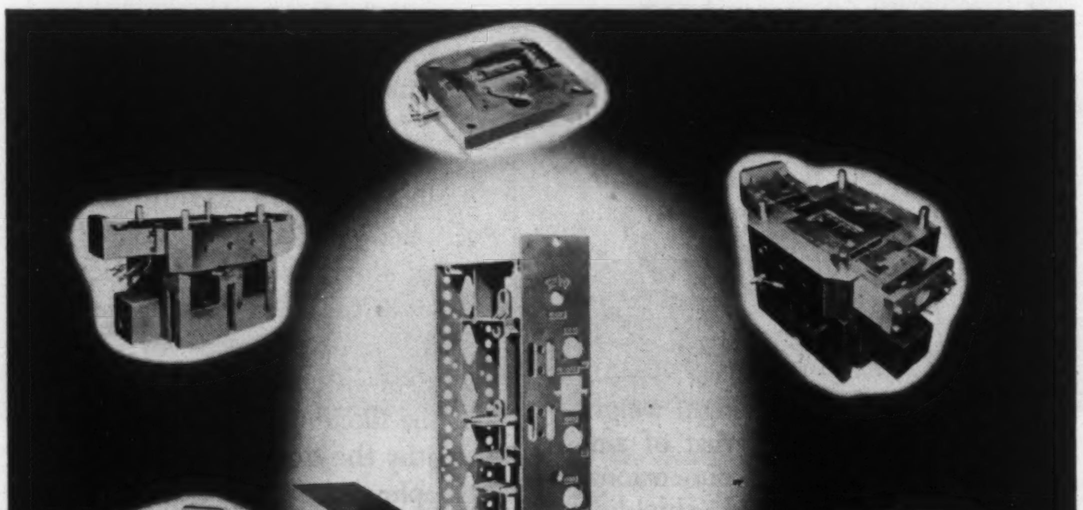


Fig 1—Large chassis for transmitting unit, surrounded by pictures of the complex die used in its manufacture. Despite low production rate and high die cost, the author claims savings of 50% over fabricated assembly.

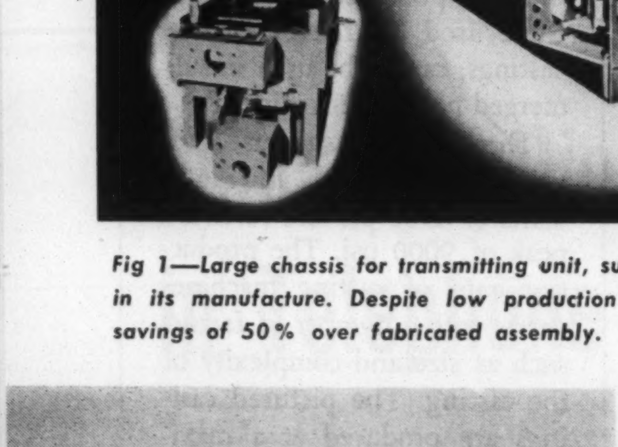


Fig 2—The three die castings used in the N1 carrier unit.

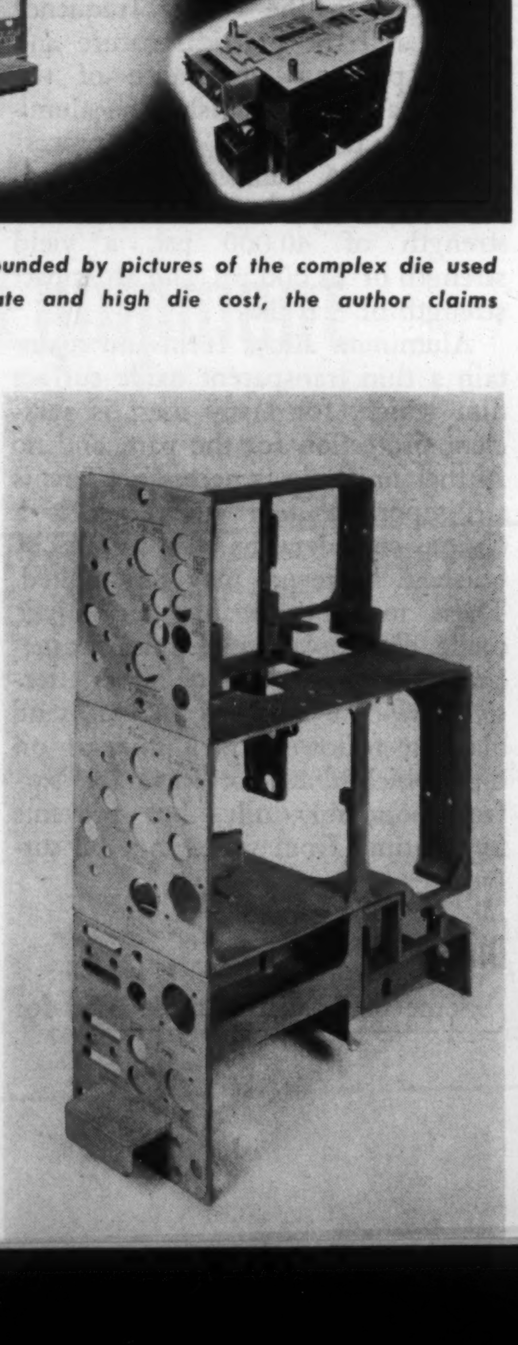


Fig 3—Castings assembled in the configuration of the completed unit.

Comparative Costs

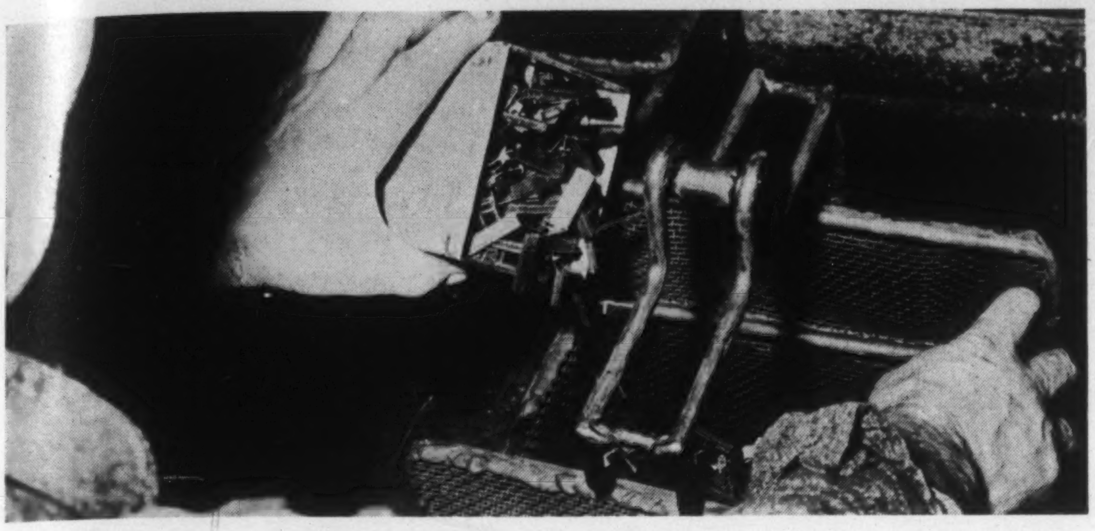
The group transmitting unit (Fig 1), a small demand item, required about 1000 die-cast units a year. Even with this relatively small demand, the unit cost, including some machining consisting of drilling and tapping a number of holes, and the part's share of die cost amortized over a four-year period, was only half the cost of a fabricated unit.

The three die-castings shown in Fig 2 are of similar complexity to the transmitting chassis, but the annual demand was 24,000 of each. These castings are used for the N1 carrier channel unit, which consists of three separate sub-assemblies mounted together to form a complete plug-in unit. Fig 3 shows the three castings assembled as they appear in the unit. Estimates in this case showed die-castings to be only about one-fourth the cost of fabricated units.

In addition to the differences in the cost of producing these castings, other differences favor the die-casting technique. Properly designed, die-castings incorporate details that otherwise must be mechanically fastened to the fabricated framework. In the N1, equipment designations and control identifications were incorporated in the die by using raised characters in recesesed areas instead of by printing or identification plates.

The art of aluminum die-casting is receiving ever-increasing attention in Bell System applications. With the present emphasis on miniaturization, both in individual components and over-all equipment assemblies, the design engineer is finding die-casting a valuable aid. Die-casting is an art, and it is one that must be thoroughly understood so the designer can realize a substantial part of its possibilities.

Adapted from article in Bell Laboratories Record, April, 1954.



Over 30,000 shaver heads per day are austempered in mechanized electric salt bath furnace. Here heads are dumped into a basket. No special fixturing is required.

by C. FAY, Chief Industrial Engineer, Schick Inc.

Austempering Thin Steel Parts Reduces Cracks, Increases Toughness

. . . Also minimizes distortion, and yields uniformly hardened parts.

● AN ELECTRIC SHAVER is a precision instrument. In its manufacture, tolerances of 0.0002 in. and surface finishes from 3 to 6 micro inches, can be considered commonplace. Distortion cannot be tolerated because in operation, a slotted piece of steel 0.006 in. thick oscillates 20 thousand times per minute in contact with another slotted piece of steel 0.003 in. thick. Further, these thin slotted pieces, or "heads", must be hard and tough.

Undoubtedly, the most difficult items to manufacture in the Schick line are the outer heads. Over 35 manufacturing processes, exclusive of washing, cleaning and inspection, are required to produce them. These stages of manufacture include piercing, blanking, forming, hardening, austempering, welding, several grinding and lapping operations, and plating. The outer head has been termed "lace" because each of these paper-thin steel stampings has 128 slots in the 1/4 in. by 1 1/8 in. cutting plane. Handling these heads through 35 separate operations requires utmost care to prevent cracking, denting bending, etc. Rejects are numerous and any means of reducing them leads to considerable savings since over 30,000 heads are manufactured daily. Replacement of the previous method of hardening by austempering cut rejects almost 4%.

Heat Treatment

A specially selected grade of high carbon steel containing vanadium is used for both inner and outer cutting heads. This steel is specified because experience proved that with shaver heads, high alloy and stainless steels are not the answer to a quality, precision product. Instead, proper heat treatment gives the results desired.

The decision to change the method of heat treating the heads was influenced by several factors: 1) rejects, due to cracking, were running high, and increased toughness was required, 2) it was desirable to hold distortion and hardness within closer limits to reduce the reject rate further, and 3) material handling during heat treatment needed streamlining. After a series of tests comparing oil quenching with austempering, an Ajax electric salt bath isothermal quenching unit was installed between the existing salt bath austenitizing furnace and a cold water rinse tank.

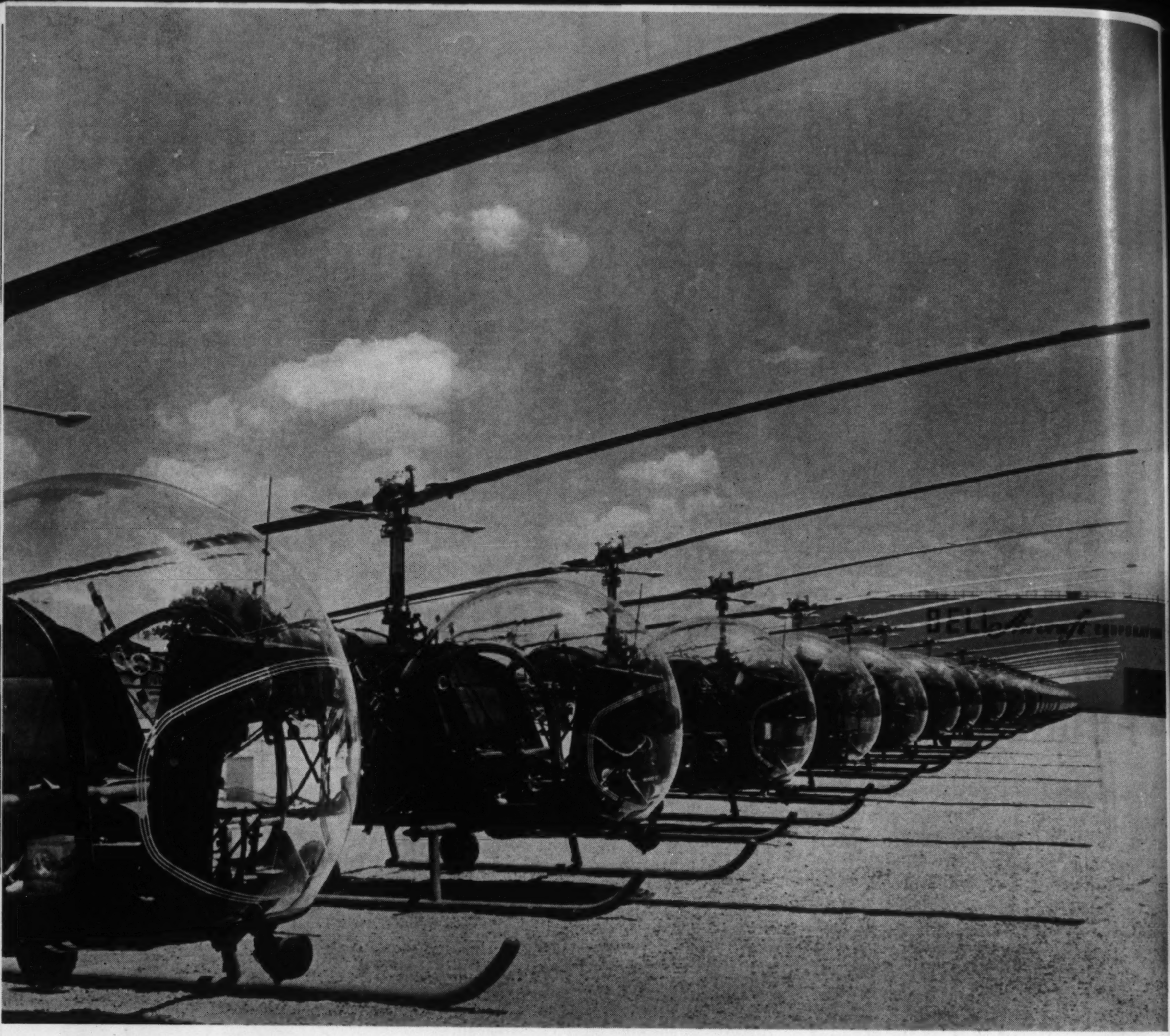
The austempering cycle for heads consists of a 5-minute pre-heat, 5 minute austenitizing in a 1550 F salt bath, 1 1/2 hours at 550 F in the isothermal quenching furnace, followed by a series of eight washing and cleaning operations. Considerable reduction in material handling resulted since the original method required all of the above operations, except for a 5-minute oil quench instead of the salt bath quench, plus five additional operations, which include a 1-hr tempering treatment at 550 F.

Results

Tougher heads are produced because austempering produces a bainitic structure without involving the martensitic change and its attendant stresses. Since stresses are avoided, cracks have been practically eliminated in the outer head. On a percentage basis, rejects because of cracks are lower than five-hundreths of one per cent. Reduction of rejects from this one factor amounts to savings of over $50,000 a year.

Reduction of cracks in the outer heads plus the increased toughness also eliminated one phase of an inspection operation. Formerly, it was necessary to examine each outer head with a jeweller's magnifying glass. This minute inspection is no longer required, and production has increased 50% at that point in the inspection line.

With austempering, distortion of heads has been easily held within limits and uniform hardness values of Rockwell 15N 86-88 has been obtained.



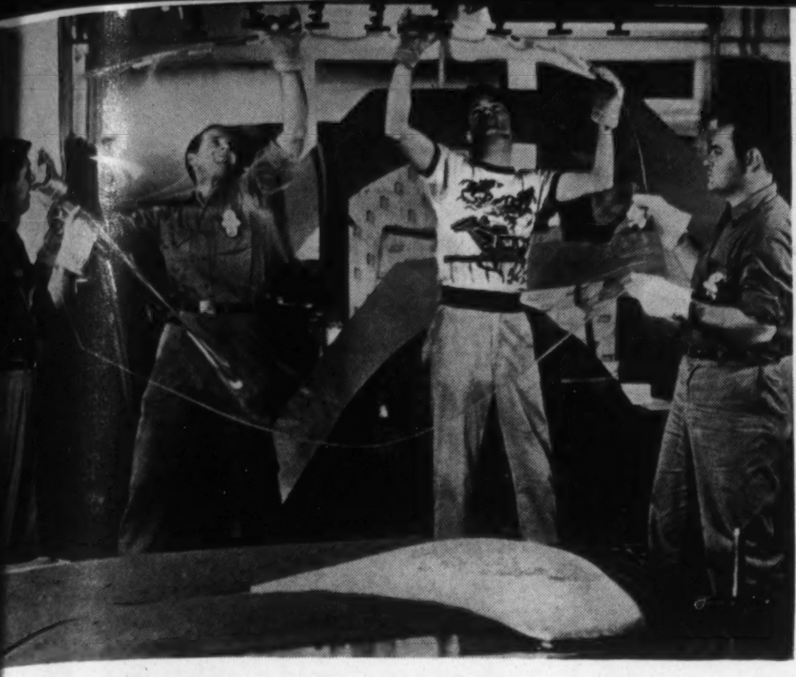
It Takes 3:00 Minutes ...To Blow The Plastic Bubble

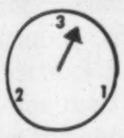
A PICTURE STORY

Acrylic bubble-like noses, such as those shown on the 47G helicopters, are free-blown at the Bell Aircraft Co. plant as shown in the accompanying pictures.

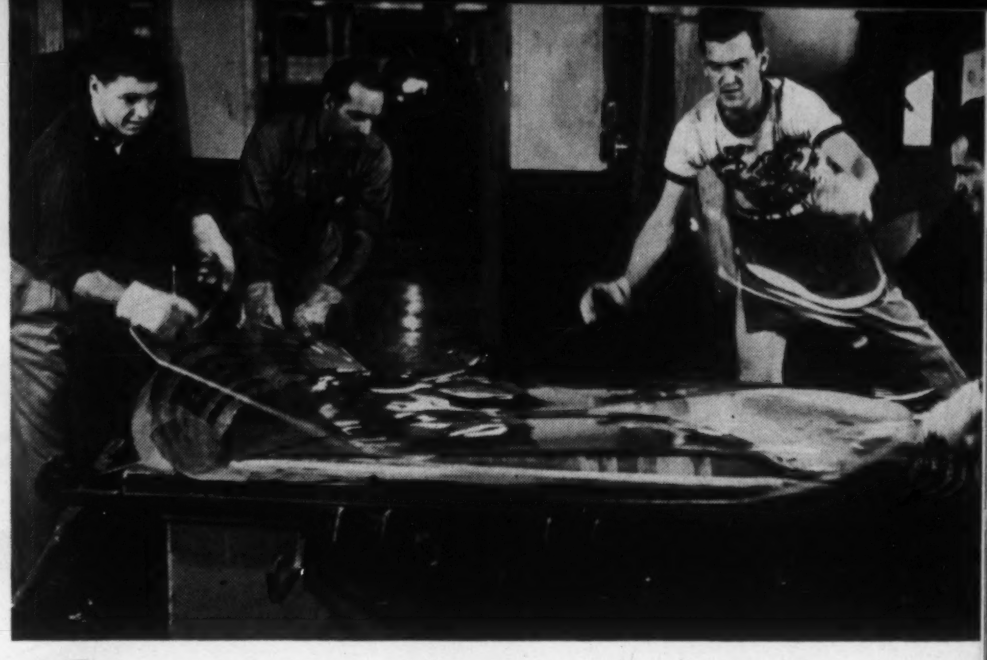
The maximum allowable time for the sheet to be formed, from the 325 F oven to finished bubble, is three minutes. During this time the air-blowing operation expands a 79- by 81-in. sheet of Plexiglas plastic into an enclosure that has 125 sq ft of surface area. The thickness of the material is reduced from 5/16 to 1/16 in.

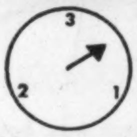
During the 15-min cooling period sufficient air pressure is maintained to hold the shape of the bubble until the plastic hardens. The resulting resilience of the nose is such that it can be pressed inward at the dome 4 to 6 in., and will snap back into original contour when pressure is released.



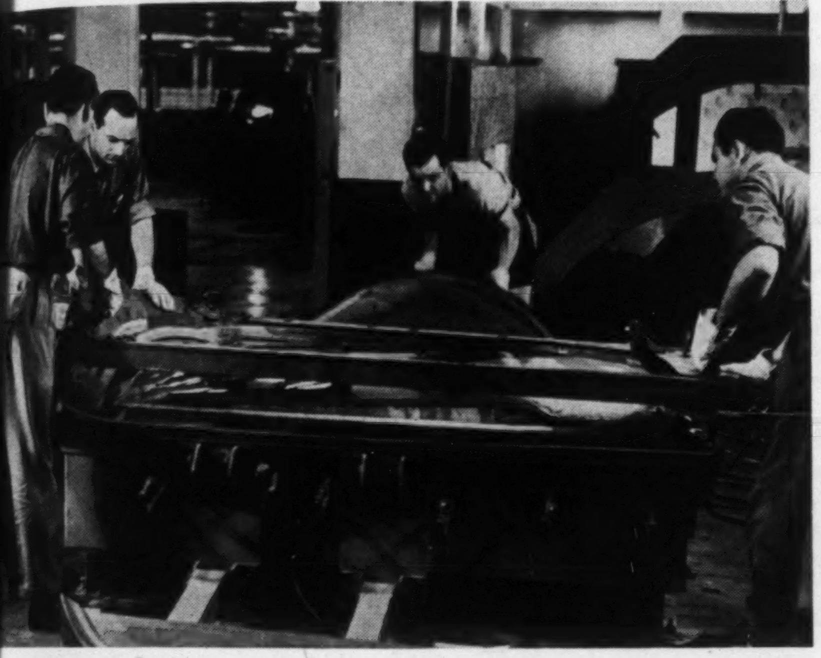


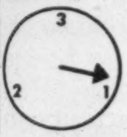
Flexible sheet comes off the track from the oven . . . . →



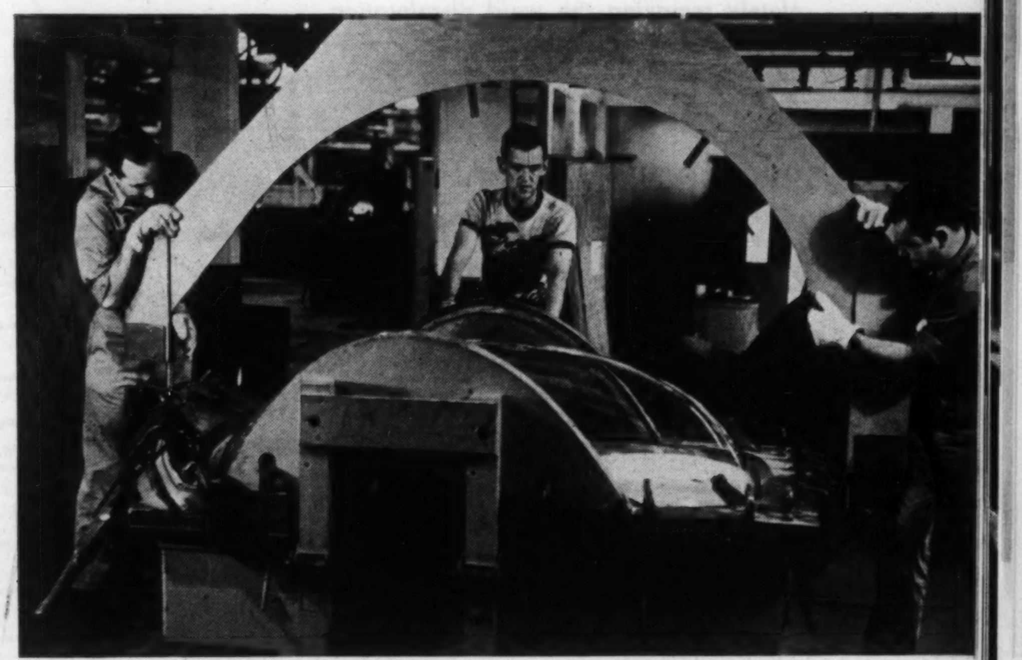


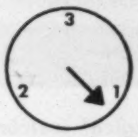
. . . . is laid on the pressure head . . . .



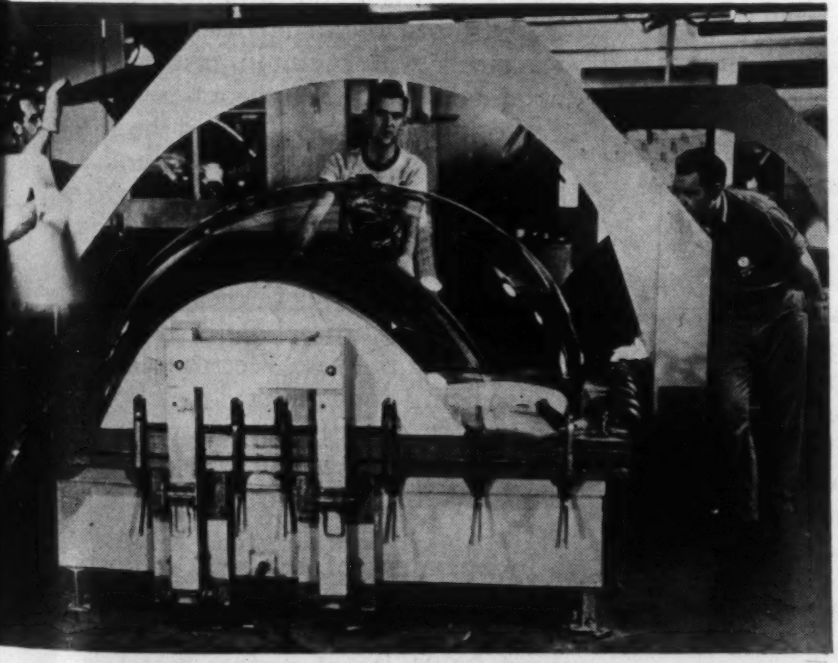


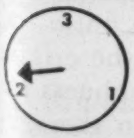
. . . . and quickly clamped down. →



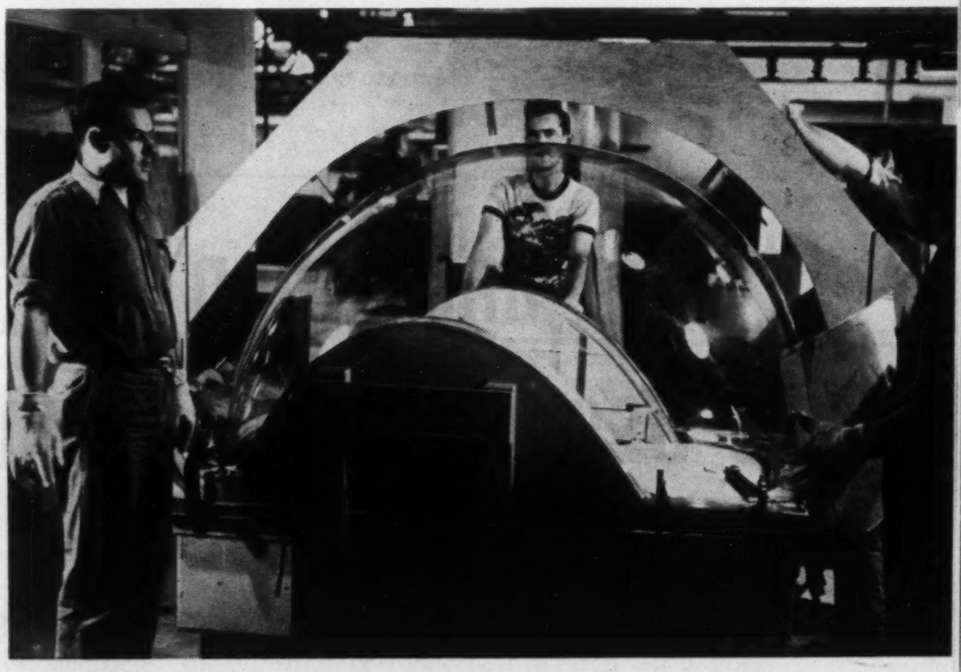


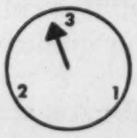
Blowing starts as template is fixed . . .



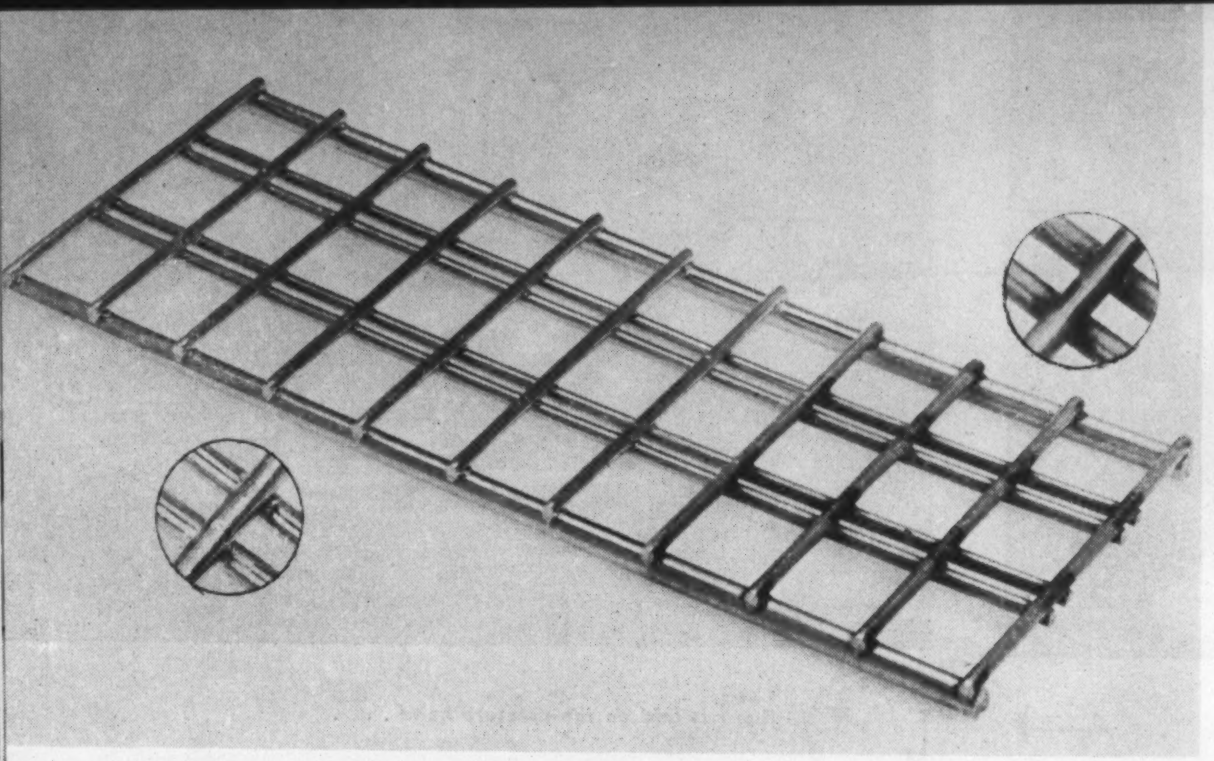


while "cardboard fans" slow down areas which are expanding too rapidly . . . →

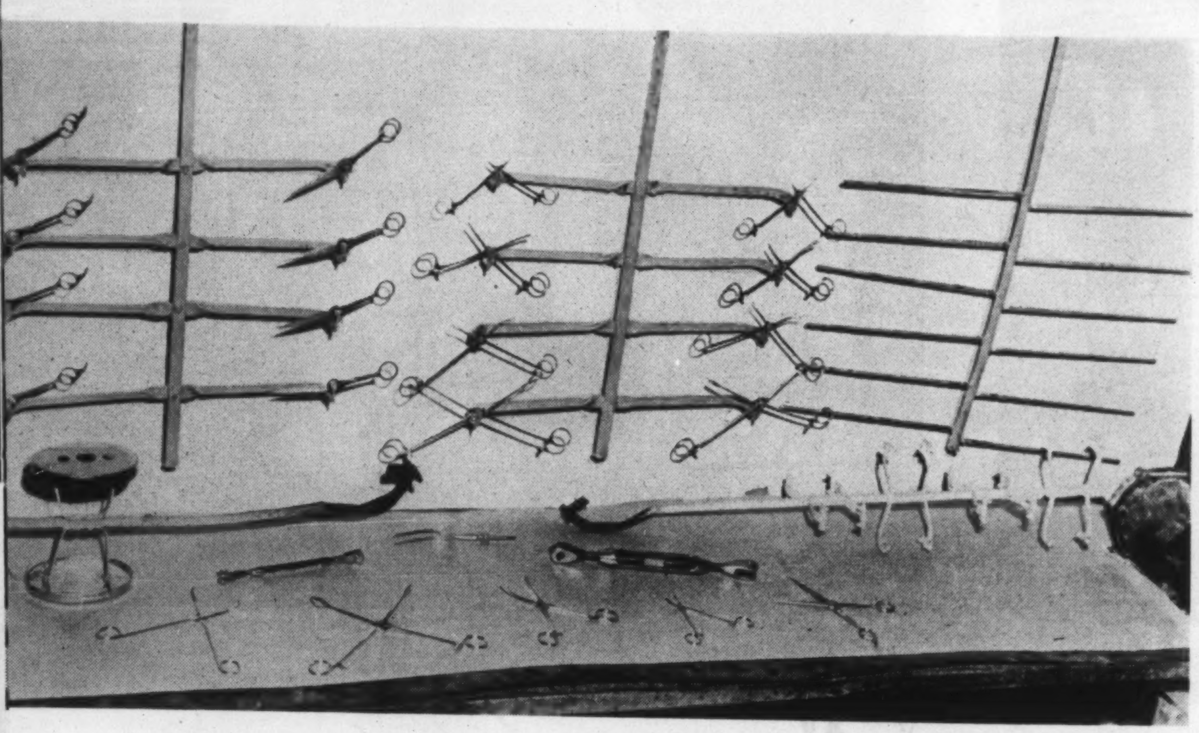




. . . . until final shape is reached.



The left hand portion of this resistance-welded wire form has been electropolished, completely removing the weld discoloration.



Electroplating-type racks used for electropolishing of surgical instruments.

Where and When to Use Electropolishing

by MALCOLM W. RILEY, Assistant Editor, Materials & Methods

As a final finish or as a preplating operation, electropolishing has many advantages. With proper equipment and procedures, almost any shape can be efficiently handled.

● ESSENTIALLY, ELECTROPOLISHING IS the reverse of the electroplating process. The material to be polished is made the anode in the electrolyte and a cathode is provided to complete the electrical circuit which causes selective removal of the anode surface. This removal of metal from the work piece levels raised areas and thus smooths and polishes the surface. In determining whether electropolishing would be the most feasible technique for polishing a certain part, the manufacturer must consider several factors: 1) type of surface desired; 2) initial surface finish; 3) type and quality of the metal part; 4) size and shape of the part; and 5) volume of production anticipated.

The Metals

A great deal of present activity in the field is centered around the electropolishing of all analyses of stainless steels, with optimum results being obtained with the chromium-nickel grades such as Type 302, and the 17% chromium Type 430. Carbon and alloy steels can also be polished effectively by the process as well as wrought aluminum alloys, copper alloys, monel, Inconel, nickel, silver, nickel-silver, Chromel, gold, and some bronzes and brasses. Electropolishing is also being done on hard metals such as tungsten, since the process provides the metal surface with the smoothness necessary for optimum electrical contact.

Independent of the type of metal being polished, it may generally be said that electropolishing to remove about 0.001 in. of surface metal can reduce the rms value of the finish to about one half the value of the original finish. When initial roughness is less than 7.5 rms, better than average electropolishing must be done to reduce to micro-inch finish to appreciably below 2 rms.

The surface of the metal to be polished has a direct effect on the ultimate surface since in most operations less than 0.001 in. of the metal is removed. In many cases, due to roughness of the original surface, mechanical polishing must be used in conjunction with electropolishing. For instance, the surface texture of a casting or one with an orange-peel effect cannot be reduced to a high luster by the amount of electropolishing that is practical for decorative finishing. Prior mechanical polishing is needed for the cutting-down operation.

A smooth surface, such as provided by cold rolling of strip or sheet stock that is cold formed, can be made mirror-like by the process while the overall quality will depend on the extent of die scuffing and the scratches due to handling. For best results the metal should be smooth, have a fine grain, and be free from surface defects exceeding the coarseness of a 180-200 grit scratch.

Table 1—Light Reflection from Polished Stainless Steel (Type 302)

Specimen	Lay[1]	Reflectance[2] Diffuse	Reflectance[2] Specular
Electropolish (1)[3]	Transverse	0.072	120
	Longitudinal	0.042	121
Electropolish (2)[3]	Transverse	0.043	124
	Longitudinal	0.023	123
No. 7 mill-finish sheet	Transverse	0.241	117
	Longitudinal	0.020	118
No. 8 mill-finish sheet	Transverse	0.614	103
	Longitudinal	0.068	104

[1] *Transverse means that the plane of incidence of the light was perpendicular to the direction of the specimen that was vertical in the electropolishing bath or perpendicular to the polishing scratches on No. 7 and No. 8 mill sheets. Longitudinal means that the light beam was parallel to those two directions.*

[2] *Averages of five readings.*

[3] *Two different electropolishing methods.*

Table 2—Relative Reflectance and Directional Effect According to Reflectances (Same Specimens as in Table 1)

Specimen	Relative Reflectance[1] Diffuse Trans.	Relative Reflectance[1] Diffuse Longi.	Relative Reflectance[1] Specular Trans.	Relative Reflectance[1] Specular Longi.	Reflectance Ratios Diffuse Trans./Longi.	Reflectance Ratios Specular Trans./Longi.
Electropolish (2)	1.0	1.0	1.0	1.0	1.9	1.01
Electropolish (1)	1.7	1.9	0.97	0.98	1.7	0.99
No. 7 mill-finish sheet	5.6	0.9	0.94	0.96	12.0	0.99
No. 8 mill-finish sheet	14.3	3.0	0.83	0.85	9.0	0.99

[1] *Based on Electropolish (2).*

Appearance

Since electropolishing removes fine surface scratches and imperfections, total light reflectance of the surface is always improved, and it will show greater brilliance and depth of color than a wheel-buffed surface. The macrosmoothness of the surface will depend on grain size and cleanliness of the metal.

A good method of comparing the smoothness of finishes obtained by this process with those obtained by mechanical polishing is by measuring the reflectance, both specular and diffuse, of the two surfaces. Specular reflectance is a measure of the intensity of light reflected from the surface. Table 1 shows the results of tests made by the Battelle Memorial Institute on specimens of Type 302 stainless steel. The higher values for specular reflectance denote a clearer image (better macrosmoothness), while the higher values for diffuse reflectance indicate a hazier surface (poorer microsmoothness).

Polishing metal by mechanical means gives a directional effect, or lay, to the surface due to the motion of the abrasive particles which remove and "smear" the metal. With electropolishing there is none of this surface effect, since the metal is selectively removed by action of the current in the electrolyte. Table 2 compares the directional effect obtained by both methods of polishing, as measured by reflectance of the surfaces.

It should be pointed out that care must be taken in calling one surface "superior" to another since there are several bases on which to judge. In some cases a burnished effect is desired on the finished part, and this would be obtained by the usual wheeled buffing and coloring processes while in others perhaps a glossy, lustrous finish might be deemed "superior," and this could well be obtained by an electropolishing process. The individual engineer must evaluate the surfacing process according to the results desired.

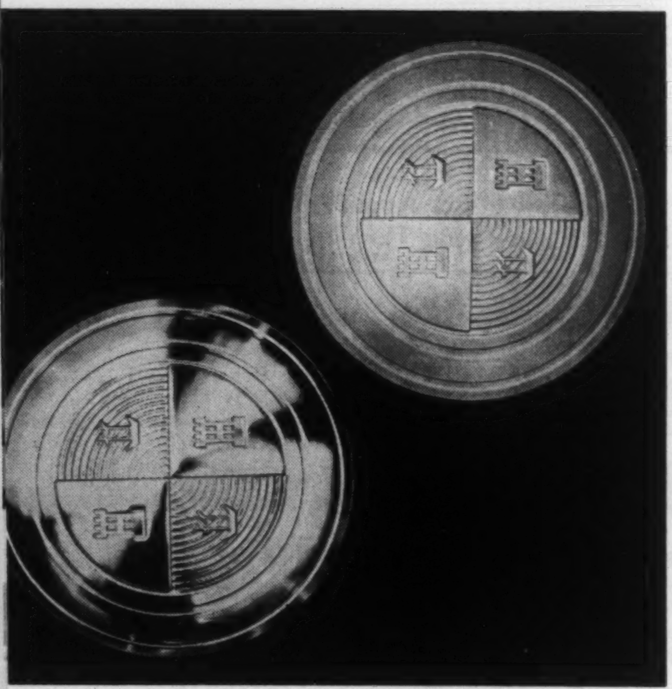
Pre-Plating

One of the most important uses for the electropolishing process is in preparing a metallic surface for plating. The process both cleans the surface thoroughly and prepares the surface in such a way that structure and adhesion of the deposit is improved.

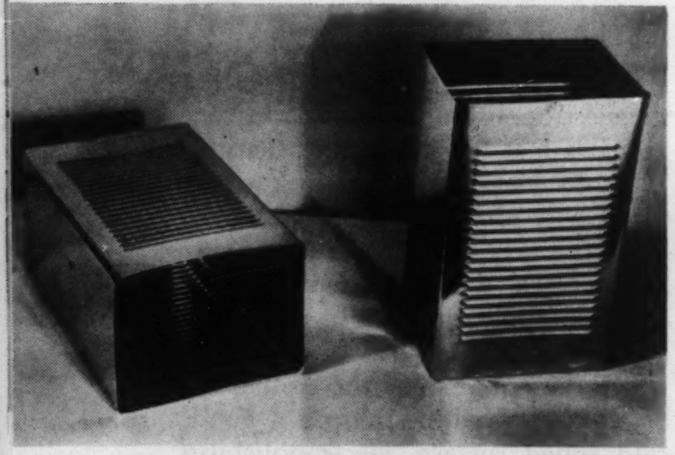
When applying a bright plate to a metal, if the part has a roughness which does not exceed the equivalent of a 180-grit belt scratch on a good, cold rolled surface, electropolishing will efficiently smooth the defects, allowing a plate with optimum finish. For rougher parts, such as castings or pickled metal, a combination of mechanical polishing and electropolishing will be required.

If a surface containing a nonmetallic inclusion is mechanically polished, then plated, the plate will bridge the inclusion and remain as a weak spot in the deposit which will tend to flake off under service stresses. Electropolishing will remove the inclusion revealing the pit and any other surface defect in the metal.

Mechanical processes such as cold rolling, polishing, buffing, grinding and machining leave a surface skin of metal that differs from the base metal in grain size, structure, orientation and strength. Tests have shown that mechanically polished surfaces contain extremely fine grains in the form of broken fragments of flowed metal on which the plate builds an exceedingly fine-grained deposit, the crystals of which bear no relationship to the true structure of the base metal. Since the electropolishing process removes a layer of metal directly, without smearing or causing the surface to flow or be worked, the surface layer contains undistorted grains of normal size on which the plate tends to build pseudomorphically. This results in bonds of maximum strength, since the base metal and the deposit form more of a single structure than in the case of the mechanically finished, plated surface.



At right, a brass medallion before, and at left, a brass medallion after electropolishing.



These stainless steel battery boxes, electropolished both inside and out, show a type of difficult job done efficiently by the process.

Applications

The way in which electropolishing accomplishes the work makes it particularly suitable for some applications which present difficult and sometimes insurmountable problems in mechanical polishing. For parts containing recesses, "gingerbread" work, or welded wire structures such as refrigerator shelves, etc., mechanical polishing is sometimes impossible. It is also difficult to hold small parts against a polishing wheel. For such parts electropolishing can be the answer depending on the type of metal used and the finish desired. Conveyed by the electrolyte, the electropolishing action reaches around and over the recesses in the parts and produces a uniform, lustrous finish. In the case of welded structures, discoloration and light scale will be removed by the polishing action, and the corrosion resistance will be improved by passivation of the entire surface.

In general, with the proper design of tank, electrode, and parts hangers, almost any shape may be efficiently electropolished. Some of the parts that have proven their suitability for this process are automobile hardware and trim, domestic plumbing fittings, hotel and restaurant equipment trim and parts, household utensils, ornamental lighting fixtures, refrigeration and packing components, and tableware.

The Process: Equipment and Requirements

Both the Battelle Memorial Institute and the Armco Steel Corp. have processes which they license to manufacturers. The two Armco processes are designed specifically for polishing stainless steels, while the Battelle processes polish both ferrous and nonferrous metals. The equipment requirements for the baths are very similar to the apparatus necessary for electroplating.

There must be a tank for the electrolyte, temperature control for the electrolyte, holding racks, suitable cathodes, and rinse tanks. For the proper electrolyte composition, current density, voltage temperature and time of polishing for each type of metal and alloy see File Facts on page 137 of this issue. In cases where the polishing time is lengthened due to roughness of the surface or particularly heavy discoloration, prolonged electropolishing does not harm the surface. The metal loss in a 10 min. period is about 0.001 in.

Limitations and Warnings

When electropolishing is contemplated, it is important to specify the type of metal desired from the supplier, since some rolling and processing operations may render the material unsuitable for electropolishing. For instance in the case of steel, it was found that the grain-size condition of the metal directly affected the occurrence of orange peel, which cannot be removed by electropolishing. Unsuitable surfaces will result from unusually severe cold-working, from special effects, such as surface decarburization, and from sensitization or carbide precipitation caused by improper heat treatment. A difficulty in choosing the right surface, stems from the fact that the suitability of a surface can not be determined by visual inspection.

The work to be polished should be cleaned first since dirt, scale, drawing compounds or oils can delay the action, causing patterns and uneven polishing.

Some general precautions which should be observed are:

1. Solution must be kept within concentration and temperature limits.
2. Positive electrical contact must be made and proper current density used.
3. Work must be racked to prevent the formation of gas pockets which will insulate the work and prevent polishing in these protected areas.
4. Cathodes must be properly shaped and positioned to suit the part to be polished, the spacing between electrode and part ranging from ½ to 8 in. depending on the nature of the part.
5. Work must be free of lime, lead, copper, cadmium, grease or other coatings.

Acknowledgments

Dr. C. L. Faust, The Battelle Development Corp.

Armco Steel Corp.

Picture Credits: Battelle Development Corp., Armco Steel Corp.

Recent Progress in Joining Titanium

Although the joining of titanium and its alloys is still a problem, suitable procedures are gradually being developed with increasing knowledge of the characteristics of the metal. Commercial titanium can be welded by a number of procedures, but the alloys, with the exception of one announced recently, still require special precautions including post-welding heat treatments and the results are variable. Suitable brazing procedures have also been developed which require the use of silver as the brazing material and special fluxes.

The two following papers discuss recent progress in joining titanium.

1. WELDING TITANIUM

by **JAMES H. JOHNSTON,** **Melting Research Engineer, Mallory-Sharon Titanium Corp.**

● THE WELDING OF TITANIUM and its alloys presents problems not unlike those found in other metals, but they are greatly magnified. Arc welding is particularly difficult and not yet practiced industrially on the alloys although several concerns are doing noteworthy work on unalloyed titanium. The difficulties are due principally to contamination by air and to structural changes occurring during welding.

Titanium is extremely reactive towards oxygen and nitrogen. Unfortunately, it not only has a strong affinity for them, but will also dissolve large amounts of both these elements. The quantity of oxygen that can be tolerated in the base material, when welding in an enclosed inert atmosphere tank, has been demonstrated to be about 0.3%, but even as little as 0.15% in unalloyed titanium causes poor physical properties of the weldment.

Nitrogen is known to be even more detrimental to ductility than oxygen. An estimated 0.05% nitrogen is now considered to be the maximum tolerable for good welds. Even though these effects of gas content were noted by adding gases during manufacture of the alloy, the same limits probably apply to gases picked up from the air during welding.

As the oxygen or nitrogen content of unalloyed titanium weldments increases, the severity of weld bead cracking and base metal cracking also increases. The cracking generally occurs after welding and can sometimes be prevented by a stress relief anneal.

Recent unpublished work demonstrates conclusively that while cracking increases with oxygen and nitrogen, cracking is not an inherent property of oxygen-containing titanium. Cracking is, instead, a direct result of constraint of the base plate on the weld deposit during cooling. This leads to the conclusion that cracking can be reduced by pre-heating the assembly to be welded to 300 to 500 F.

These observations of the effect of oxygen and nitrogen apply only to the actual heats tested and are affected by other variables, but basically they apply to all titanium and titanium alloys.

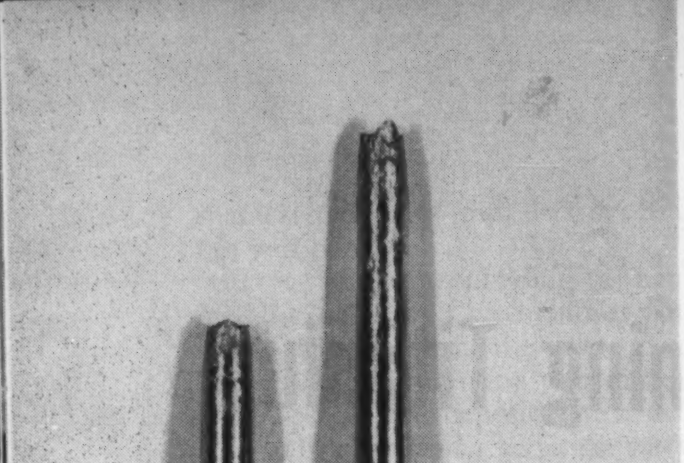
Inert-Gas Shielded Arc Welding

Adequate inert-gas protection is absolutely necessary as the first step in successful welding. Although perfect oxidation protection is secured only in a gas-tight pure-inert-gas welding tank, satisfactory shielding can be obtained with either the non-consumable tungsten torch or with an automatic inert-gas gun. Trailing gas shields behind the gun, to protect the cooling weldment, are currently a must and inert-gas backing should be used. A heavy copper block with a shallow groove cut in it under the weld is commonly used.

An atmospheric protection device consisting of a bag that covers the torch bead and travels with the torch has been developed. While trouble with vision caused by condensing metal vapors and with heat from the arc will undoubtedly be experienced, this system is well worth considering for production use.

No weaving can be tolerated, filler wire used with Heliarc equipment must not be pulled out of the protective gas blanket during welding, back filling must be avoided, and both filler metal and pieces to be joined must be completely free of oxides before welding. Multiple passes should be avoided because of an increasing cracking tendency, but when multiple passes are necessary, grinding or sandblasting between passes should be employed to remove surface oxides. At present, it is recommended that pickling, as a means of removing oxides, should be avoided because of a current controversy over deleterious hydrogen pickup.

Helium or argon can be used for protective atmospheres. Helium gas permits faster welding; argon is believed to give better protection. In recent work, mixtures of the two were found to give the best results. Actual



Trailing gas shield is a must in inert-gas-shielded arc welding titanium. This all-weld metal tensile specimen obtained with commercially pure titanium electrode and using trailing shield had elongation of 17%. Similar specimen made without trailing shield had zero elongation.

gas flow rates and position or location of the welding nozzle and shield are of utmost importance. No welding should be done where there is a draft to disturb the gas flow.

When the proper set-up has been achieved, welds have glossy metallic finishes without any signs of oxides on either top or bottom of bead. It might be noted at this point that until such shiny-metallic white beads have been obtained, there is no need whatsoever of making physical tests of the joints produced. The criterion of bright shiny bead surfaces is an ample test for oxidation pickup.

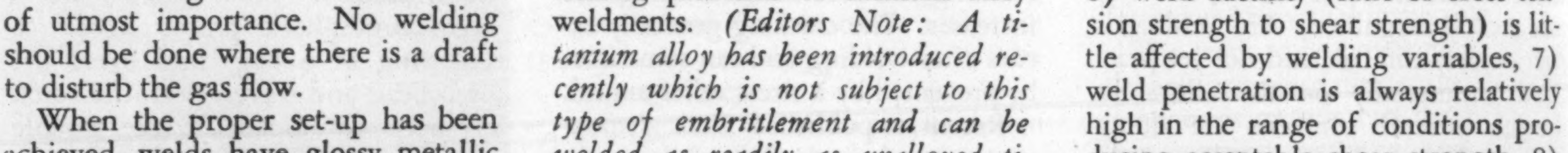
Adequate gas protection cannot be over emphasized, but even perfect oxidation protection is not enough. Heat treatment during welding, the possibilities of post welding heat treatment and choice of both base metal and filler metal are equally important. Even with perfect inert gas protection, embrittlement of the weld still occurs in all the commercial alloys currently marketed.

The basic metallurgical difficulty occurring during welding of titanium alloys is overheating of the base metal adjacent to the fusion zone, which causes embrittlement due in part to grain growth and in some cases to grain boundary precipitates. Even though, it is not yet known how to prevent or refine this large grain size, certain heat treatments have been reported that alleviate the embrittlement. Manufacturers using post-welding heat treatments do not have 100 per cent success, and it is certain that there is considerable variation from heat to heat of any one alloy. Experimental work in post-welding is progressing rapidly and encouraging results can be expected soon that will solve some of the metallurgical heat treating problems of titanium alloy weldments. *(Editors Note: A titanium alloy has been introduced recently which is not subject to this type of embrittlement and can be welded as readily as unalloyed titanium).*

Because unalloyed titanium of low hardness can be welded with commercial equipment to produce a ductile weld without heat treatment, it is recommended that any welding contemplated with titanium alloys be preceded by an extensive program of welding and testing unalloyed titanium of low hardness. This practice will give control over the first of the two major problems, namely atmospheric protection. When proper welding conditions are established for the most ductile unalloyed titanium weld, development of titanium alloy weldments has a firm foundation.

Spot Welding

Spot welding of commercially pure titanium is easy. Inert gas protection is entirely unnecessary, although cleaning of sheets by pickling is desirable. Optimum conditions have been established and consistently reliable results can be expected. Several conclusions can be stated: 1) oxygen and nitrogen content of sheet material must be low, 2) carbon content must not exceed 0.25% (although this value is affected by other variables), 3) weld strength is not affected by the direction in which sheet is rolled, 4) cleaning of the sheet by acid pickling prior to welding improves consistency of results but is not necessary for production work, 5) variations in electrode contour between 3-in. radius and 10-in. radius do not appreciably effect weld shear or tension strength, 6) weld ductility (ratio of cross tension strength to shear strength) is little affected by welding variables, 7) weld penetration is always relatively high in the range of conditions producing acceptable shear strength, 8) the welding range is wide and need not be controlled too precisely except when particular strength welds are required, 9) weld force is not particularly important, 10) standard equipment of the single phase a.c. type with good quality timer control is quite



Left, face bend (180-deg NF) of joint made in 3/8-in. commercially pure titanium using Aircomatic process. Specimen was taken from plate shown at right.

suitable.

All titanium alloy spot welds have low cross-tension strength, because of the severe notch sensitivity of titanium. Heat treatment studies whose object is to improve impact properties may also be expected to alleviate the low cross-tension properties of titanium spot welds.

Flash Welding

Flash welding has a distinct advantage over other types of fusion welding because the molten portion which has been contaminated by air is partially ejected from the weld. However, argon gas shielded welds are distinctly more ductile than non-shielded welds. Die burns are a problem which must be corrected, to avoid breakage, by close fitting dies. Titanium alloy weldments are again subjected to the same embrittlement found in arc welding regardless of contamination, and again heat treatment research and alloy development may be expected to alleviate this.

Other Welding Methods

Flux coated titanium electrodes are not available, nor are they likely to be for many years, if ever. Fluxes for submerged melt welding are not available. Oxyacetylene welding cannot be done on titanium. Nothing has yet been done on percussion welding, and resistance butt welding is not satisfactory.

Summary

The two major difficulties in titanium welding are air contamination and changes in thermal conditions occurring at or adjacent to the weld. No actual set-ups are reported here because different laboratories and production groups using apparently identical set-ups are reporting different results.

It is strongly recommended that any welding program be preceded by: 1) extensive inquiry into available literature, 2) consultation with manufacturers of titanium metals and its alloys, 3) use of unalloyed low-hardness (low oxygen) titanium as a guide to correct welding procedure.

2. BRAZING OF TITANIUM

by **N. A. DeCECCO,** Armour Research Foundation
and **JOHN M. PARKS,** Air Reduction Research Laboratories

● COMMERCIALLY PURE TITANIUM can be brazed with an oxyacetylene torch, by electrical resistance heating and by heating in an inert-gas atmosphere furnace.

Several factors must be taken into consideration when brazing a highly reactive metal like titanium. Finding the proper brazing alloy and flux is most important. Associated with this problem are wetting and metal flow, selection of the heating method and metal protection during brazing.

A large number of metals react with titanium to form brittle intermetallic compounds. Such metals when used as brazing alloys limit the use of brazed joints to designs in which only shear loading is significant. Therefore, it is important to select a brazing alloy which does not form brittle intermetallic compounds.

Silver, copper and aluminum have been investigated as brazing metals. Of the three, silver forms a ductile intermetallic compound with titanium. Copper forms a brittle intermetallic compound while aluminum forms two compounds, one of which is ductile and the other is brittle.

Fluxes

Molten metals wet and flow on solid metal surfaces provided these surfaces are free from non-metallic films. The purpose of a flux is to remove such films. Fluxes which have been available are operative because of one or both of the following: 1) removal of the film by physical absorption or chemical solution or 2) attack of the surface metal beneath the film thereby loosening it mechanically so that it may separate from the titanium surface when the flux or metal covers it.

A commercial fluoride flux has been developed which is satisfactory for brazing with low melting point silver brazing alloys. However it is not satisfactory for brazing with fine silver or high melting point alloys because it contains no mechanism for protecting the titanium from severe oxidation at these higher temperatures. Accordingly a new principle was applied to flux development—electrochemical deposition of a metal protecting film.

Molten chlorides of silver, copper, tin or manganese react with titanium surfaces, deposit metal films which protect the metal from subsequent oxidation and release gaseous titanium chloride which aids in disrupting non-metallic films on the surface.

The use of pure salts, however, is not generally desirable because the higher melting points of metal depositing salts compared with salt mixtures. The higher the melting temperature of the flux, the greater is the degree of surface oxidation before the flux covers the surface and deposits a protecting film, and the slower the effective action of the flux becomes.

Therefore, low melting mixtures of chlorides with metal depositing salts were investigated. The following general observations were made: 1) to secure flow of fine silver on titanium using an oxyacetylene torch, the flux required a metal depositing reagent, 2) silver chloride was the best metal depositing flux reagent for silver brazing, 3) lithium salts were necessary reagents to use in conjunction with metal depositing fluxes, 4) manganese chloride and copper chloride were poor metal depositing reagents for torch brazing although they were quite successful in inert atmospheres, 5) tin chloride in the flux caused silver to rapidly spread and then disperse; hence, it was not considered a satisfactory metal depositing agent for silver brazing.

The next stage in the evaluation of fluxes for brazing fine silver was to determine their ability to produce complete, uniform flow in lap joints consistently. By observing the fracture and shear strengths of a large number of brazed joints, six experimental fluxes were evolved. The composition of these fluxes and a commercial titanium brazing flux, which was analyzed as a part of this investigation, are tabulated.

Fluxes for Oxyacetylene Torch Heated Brazed Joints

Flux	Composition									
	AgCl	Cu_2Cl_2	$MnCl_2$	KF	KCl	NaF	LiF[b]	LiCl	NaCl	$SrCl_2$
A	10	—	—	—	36.0	—	9.0	—	45.0	—
B	5	—	—	—	38.0	—	9.5	—	47.5	—
C	3	—	—	—	38.8	—	9.7	—	48.5	—
D	4	1	—	50	—	—	45.0	—	—	—
E	4	—	—	50	—	—	46.0	—	—	—
F	—	—	25	25	—	—	—	50.0	—	—
G[a]	—	1	—	46	—	2	—	50.0	—	1

[a] *A commercial flux developed for brazing titanium. The dry composition was determined by a chemical analysis. The flux is 75% solids and 25%* H_2O.

[b] *Lithium chloride was found to be essentially equivalent to lithium fluoride in fluxes A, B, and C.*

Oxyacetylene Brazed Lap Joints

To evaluate the effectiveness of various brazing alloys and fluxes for lap brazing titanium to itself and to stainless steel, iron and aluminum, a fixture was made and a procedure established for brazing 1/8-in. thick sheet using a 1/8-in. overlap.

Cleaned specimens were mounted in the fixture, a 1¼-in. length of brazing wire placed upon the edge of the joint, and the entire edge covered with flux. Brazing was performed with a single gas torch by moving rapidly from one side to the other; later, a double tip torch was substituted for making test specimens. With this torch, it was possible to obtain faster and more uniform heating. For all test specimens, the joint was brazed at a minimum temperature in as short a time as possible.

Fine silver and several commercial brazing alloys were then evaluated using several of the fluxes shown in the table. Shear strengths were determined for a nominal 1/8-in. overlap joint having a small fillet by measuring the shear load and dividing this value by the actual sheared area of the fractured overlap surface. All joints brazed with fine silver broke in ductile shear. Joints brazed with the low melting point silver-copper-zinc-cadmium brazing alloy, broke with brittle shear fractures. The brittleness was attributed to the copper content of the alloy; copper forms brittle intermetallic compounds with titanium.

To estimate the influence of zinc and cadmium on joint brittleness, joints were brazed with 8.5% zinc—91.5% silver and 18.4% cadmium—81.6% silver alloys. Although both alloys eroded titanium to a slight degree, joints made with each broke with a ductile fracture. On the other hand, joints made with 3% copper—97% silver alloy broke with a brittle fracture. From this, it was concluded that the copper content of the silver-copper-zinc-cadmium alloy was responsible for joint brittleness.

Studies were made of brazing titanium to stainless steel and exploratory tests were made trying to braze titanium to iron and aluminum. The problems involved and the work required to find a satisfactory brazing alloy and flux combination were discouraging. In the case of stainless steel, no satisfactory brazing alloy and procedure were found. Pure silver could not be made to wet and flow on stainless steel. All joints that were made with the silver base alloys, were extremely brittle at the stainless steel-braze metal interface; often joints broke in handling. The solution of titanium in the brazing alloy and its reaction with stainless steel to form brittle films at the stainless steel-brazing alloy interface is believed to be the metallurgical cause of brittleness. Considerable effort will have to be expended, studying diffusion barrier layers, in order to overcome this detrimental effect.

With regard to brazing aluminum to titanium, the aluminum, the titanium brazing fluxes and the potential brazing allovs have melting points in such proximity that a difficult experimental problem is posed when braze joining titanium to aluminum is attempted.

Furnace Brazing

Furnace brazing in an inert-gas atmosphere is a simple method of brazing as far as fluxing is concerned; however, it requires a longer time cycle and as a result, metal alloying proceeds to a much greater degree. With regard to titanium this permits metal combinations to produce thick film layers with consequent loss in joint ductility and somewhat lesser joint strength.

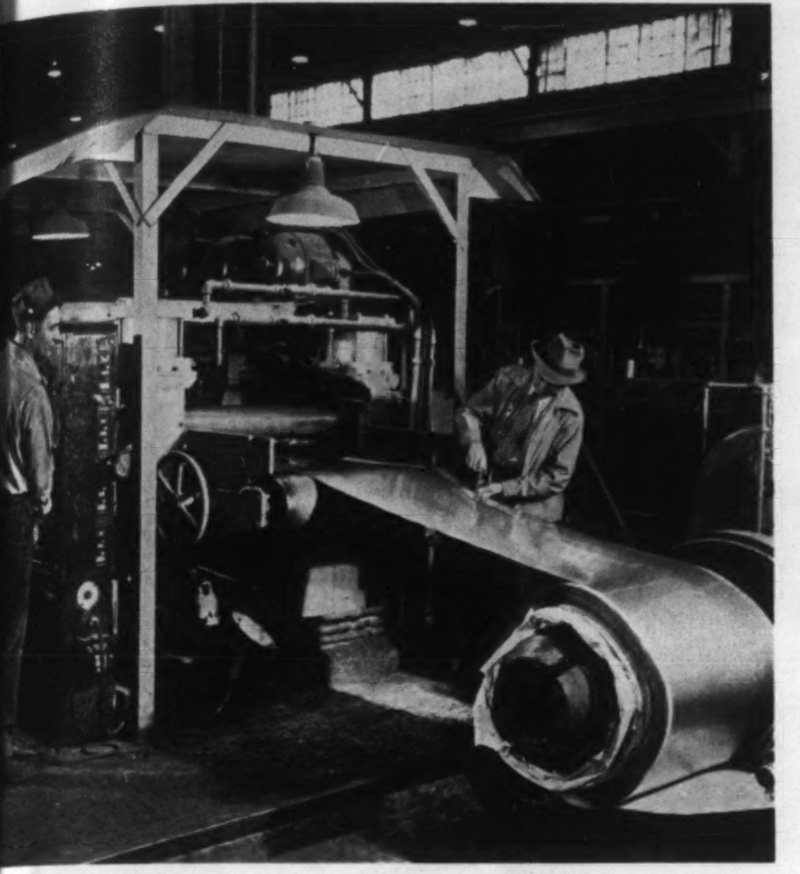
The basic advantage to furnace brazing lies in its ability to braze structures while maintaining a protective atmosphere. However, the metallurgy and joint properties are, at best, equivalent to those already discussed.

Resistance Brazing

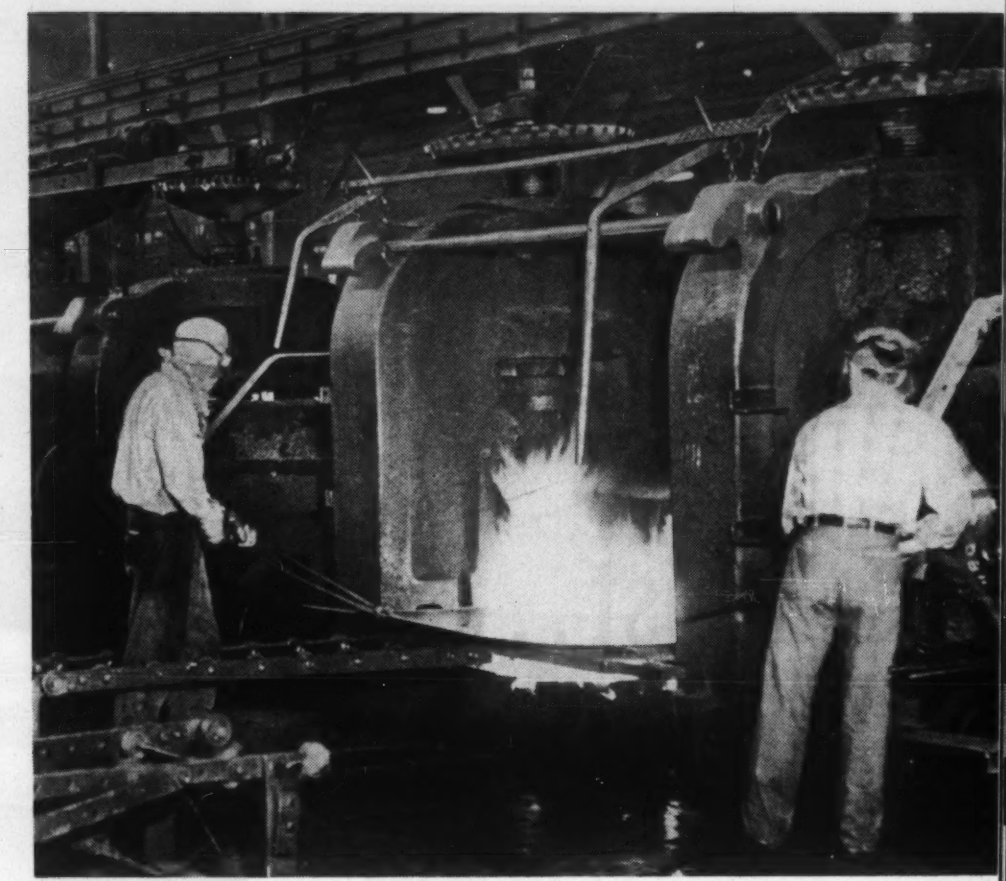
A limited study of resistance brazed titanium joints was made. For 1/8-in. sheet, 1 in. wide, or 3/32-in. sheet, ½ in. wide, a 3/16-in. overlap was used. A 3/16-in. wide brazing alloy sheet was placed in the joint interface after preparing the surfaces to be brazed using sandblasting followed by a 10% hydrofluoric acid pickle.

Copper electrodes are recommended over graphite and other high electrical resistance electrode materials. Titanium has more than adequate electrical resistance to heat the faying surfaces; consequently, water-cooled high conductivity copper alloys are the best electrode materials.

Three factors must be controlled when making a resistance brazed joint, namely: 1) electrode pressure, 2) current density, and 3) heating time. The selection of each was made on a trial-and-error basis. The principal difficulty encountered, using short brazing times, was non-uniform heating resulting from slight variations in total lap thickness and sheet geometry. In general, the joint center was heated to the melting point of the braze metal while the braze metal at the edges remained solid and bonded only by interdiffusion or recrystallization forces; if the brazing current was raised further to fuse the joint edges, the braze metal in the center was superheated, alloyed and inwashed with the titanium, and was squeezed out of the joint to form objectionably large fillets.



Titanium sheet coming off a continuous pickling line.



Hot rolling titanium in a hand sheet mill.

This effect was reflected in the fracture pattern of broken test specimens; it had an elongated elliptical spot in the center of the fracture, corresponding to the hot zone produced on brazing.

Using high currents and short times (5 to 8 cycles), a series of fine silver resistance brazed joints was made. Such a procedure produced some joints having a high shear strength. With lower currents and longer times (6 sec to 4 min), joints having strengths shown in the table were produced. The difference in joint strength is related to the degree of hot forging rather than to brazing time; longer brazing time encourages greater hot deformation, which is the real cause of the increased strength; joints made with long times, but little deformation, are relatively weak.

Ultimate Shear Strength of Resistance Heated Single 3/16-in. Lap Joints Brazed with Fine Silver

Specimen No.	Time of Heating	Approximate % of Hot Forging	Ultimate Shear Strength, psi	Description of Joint
1	6 sec	None	20,300	Ductile shear fracture in silver. Silver did not fuse.
2	1 min	None	23,750	Silver fused in lap interior. Silver in joint edges did not fuse.
3	1 min, 12 sec	20	27,200	Small amount of brazed metal squeezed out of joint.
4	2 min	None	17,800	Silver fused in center of lap area. No brazed metal squeezed out of joint. Heating current approximately 90% of amperage used in specimens 1, 2 and 3.
5	2 min	None	16,430	Ductile shear fracture in silver. Silver did not fuse. Heating current approximately 80% of amperage used in specimens 1, 2 and 3.
6	4 min	None	18,700	Same as specimen No. 5.

Specimen size: 3/32 x 1/2-in. titanium strip. Thickness of fine silver sheet: 10 mils. Electrode pressure: 300 lb.

The point of least electrical resistance and greatest heat generation usually occurred at the center of the lap. On a second heating cycle, it occurred elsewhere. This suggested a repeated heating technique to assure greater probability of the entire joint receiving a more uniform maximum temperature throughout at some time during resistance brazing.

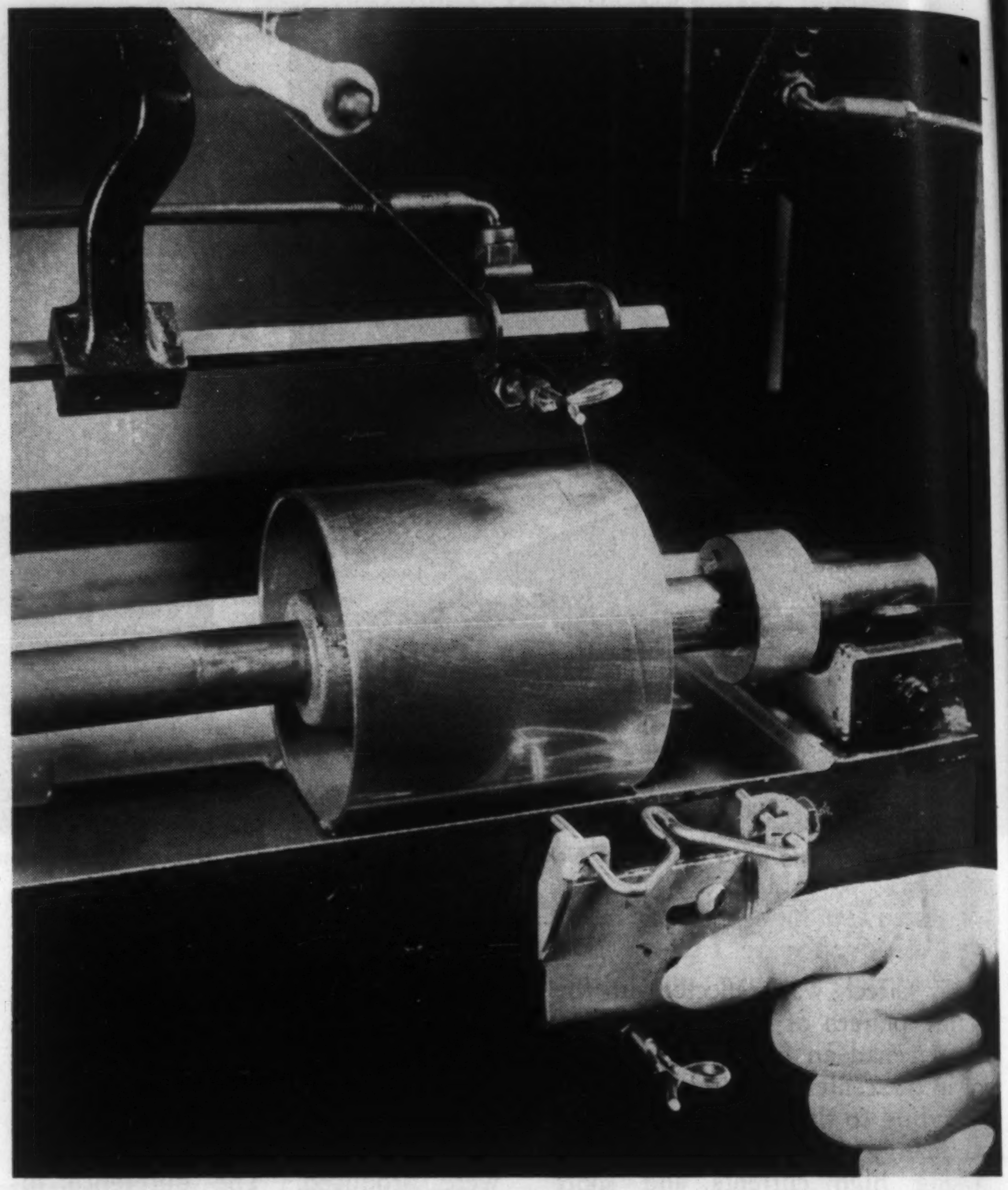
Joints were brazed with fine silver using a repeated heating technique. The conditions and results are described in a table.

It was possible to braze joints with pure copper by using the repeated heating technique. Copper foil, 1 mil thick, was used in order to minimize the quantity of titanium-copper eutectic melt formed and the brazing temperature was kept to a minimum to reduce the tendency of the eutectic melt to erode titanium. The joints produced by this method are described in a table; the joint strengths were such that a number broke in the base metal rather than at the joint interface.

Adapted from The Welding Journal, Nov., 1953.

Picture Credits: Air Reduction Sales Co., Titanium Metals Corp. of America

Synthetic Sapphire Parts Resist . . . → Wear



Thread guides for the textile industry give low friction. Extremely abrasive fibers traveling at high speed cut grooves in ordinary guides and fray thread. Synthetic sapphires outwear metal or porcelain guides. Acid solutions from which some synthetic fibers are precipitated do not attack sapphire. The polished jewel surfaces also resist lint accumulation. Guides must be redesigned for sapphires, however. Shapes made in metals and ceramics can not be duplicated. Newer guides use less sapphire by mounting the jewels in inexpensive plastic or metal holders to eliminate redesigning.

● SYNTHETIC SAPPHIRE is still an expensive engineering material. In many specialized applications, however, the cost is outweighed by outstanding properties. Sapphire lenses, for example, give special optical effects and withstand high temperatures and corrosive conditions. Windows are made for combustion and chemical vessels. In most industrial parts, however, the selling point is hardness.

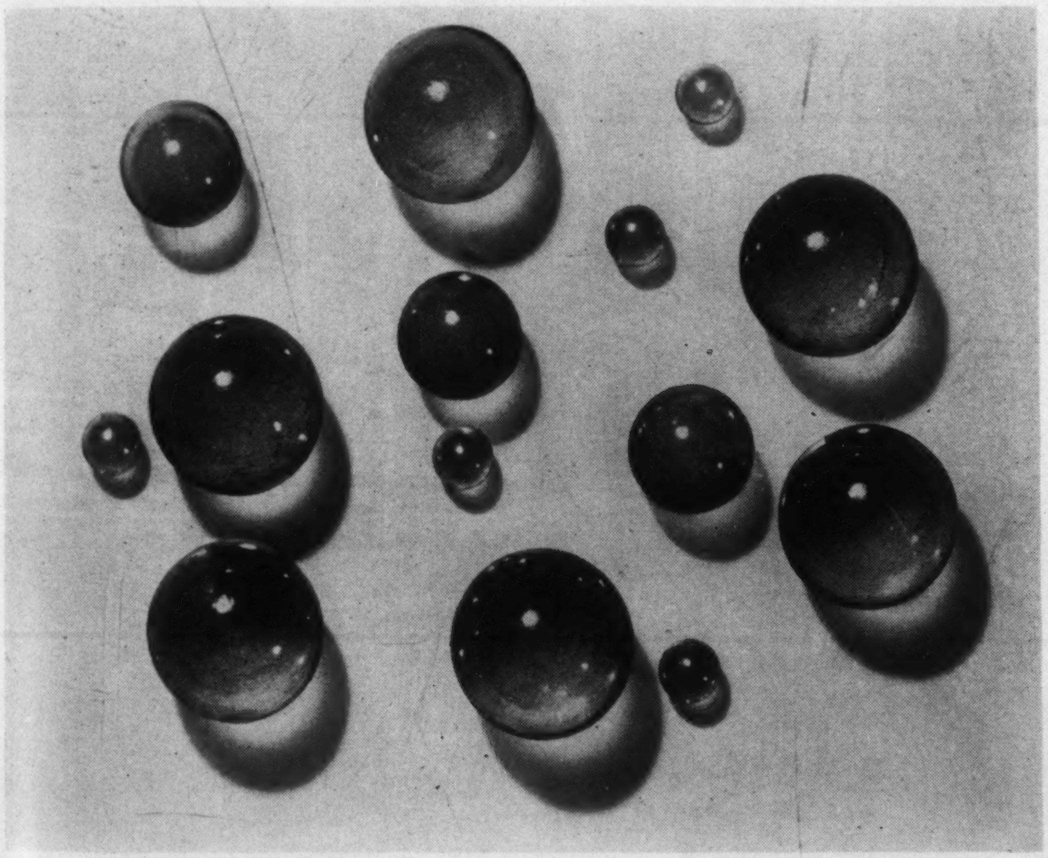
On the Moh scale, sapphire is 9–1 below diamond. Synthetic sapphire is much cheaper than diamond, though, and can be made comparitively easily in special shapes with close tolerances.

The most conventional use is bearings for watches, instruments and meters. Main watch bearings operate ½ million times in 20 years. Compasses, aircraft instruments, ammeters and voltmeters are other bearing users. Journal and thrust bearings range up to ⅞-in. o.d. Hard, low-friction sapphire surfaces are ideal for the high pressure exerted over tiny bearing areas. In these bearings, there are no shock loads to damage the relatively brittle jewels. In most other industrial sapphire applications requirements are similar. Hardness and low friction are needed in recording stylii, for example.

Synthetic sapphires are available from Linde Air Products Co. in this country as boules (up to 0.230 in. in dia and up to 18 in. long in smaller diameters), and as rods and balls (from 1 mm to ½ in. in diameter). They can be fabricated to practically any form by cutting, grinding, polishing, flame forming and by bonding to other materials. Gages resist wear and hold dimensions because of the hardness of sapphire. Plug and ring gages are made commercially. Go-no-go gages can not be made much above ½ in. in dia. They do not deform in use, although they may chip. Single crystal rods up to ¼ in. in dia and up to 18 in. long in some diameters can be supplied as-grown or centerless-ground.

Heat

Insulating spacers in electronic equipment are made to close tolerences. Strength is retained at high temperatures, and sapphire is a good insulator. No gases are absorbed and these spacers can be used in vacuum tubs. Wire guides for lamp filaments are used to maintain the pitch between filament coils. Tiny galvanometer coils used in miniaturization of electronic equipment are made to close tolerances with sapphire spacers.



Corrosion

Sapphire balls resist wear in ball point pens. Balls are also used in tapered tube flow meters and rhotometers where corrosion is a problem and great dimensional accuracy must be held. Liquid chlorine can be handled, for example. Balls are used in light load ball bearings not subject to shock. Spacers for electronic equipment are another ball application. Sphericity tolerances of 0.00002 in. can be held on balls 3/3 in. in dia or smaller.

Chemical Formula	Al_2O_3
Crystal System	Hexagonal c a
Melting Point	3685 F
Hardness Moh	9
Hardness Knoop	1525 to 2000
Specific Gravity	3.98
Specific Heat (77F)	0.18
Water Absorption	0
Chemical Resistance	Unattacked by common acids or NaOH; by HF up to 570F
Thermal Expansion Coefficient (per °F x 10^{-6})	3.72 (122F) 2.78
Refractive Index (at 5893 Å n_d)	1.769 1.760
Chromatic Dispersion (n_f-n_{C}, 6563 – 4861 Å)	0.011 0.011
Infrared Transmission (Loss largely due to Fresnel's reflection)	83% (for 5mm thickness at 10,000 Å)
Infrared Limit of Transparency	57,000 Å (30% transmission, 5mm thickness)
Dielectric Constant	7.5 to 10.0
Electrical Resistance	T_e point Temperature at which specific resistance becomes 1 megohm 2248 F 2217 F
Compressive Strength	300,000 psi
Elastic* Modulus in Flexure (psi)	56×10^6 50×10^6 75° 60° 45° 51×10^6 30° 55×10^6
Maximum Bending Stress* (Modulus of Rupture) (psi)	94,000 75° 60° 65,000 40° 78,000 30° 100,000

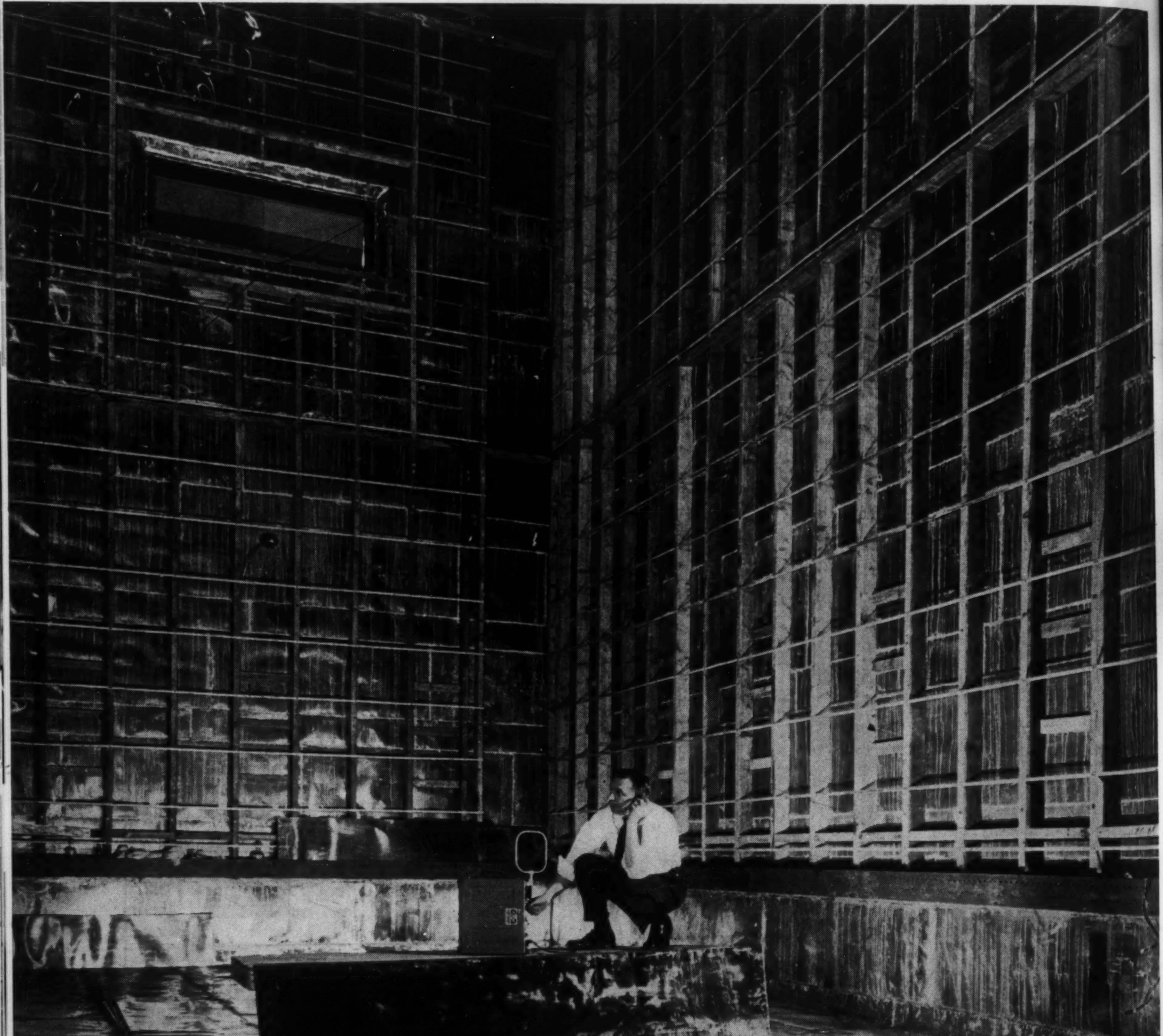
NOTE: Coloring agents added to water-clear sapphire affect optical and electrical properties.
Coloring is sometimes used to give the colorless material definite, useful properties.
The properties listed here are for the colorless variety of sapphire.
*Sample with C-axis in relation to sample axis

Materials at Work

Here is materials engineering in action . . .

New materials in their intended uses . . .

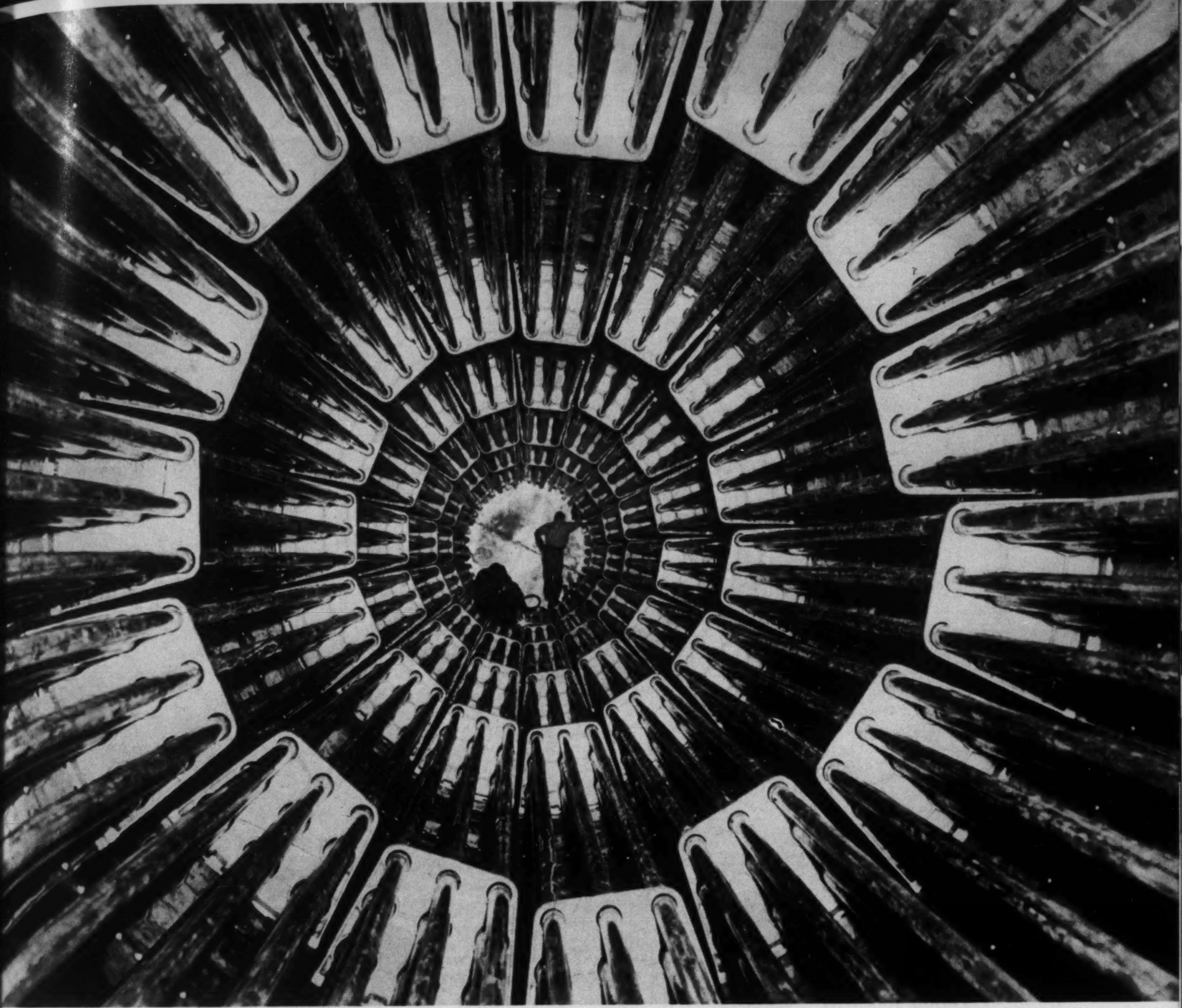
Older, basic materials in new applications . . .



Copper Lining A total of 20,900 lb of copper sheeting is used to seal this anechoic chamber from externally generated electromagnetic waves.

Built for General Electric's Transformer Div., the room has walls 4½ ft thick incorporating concrete, masonry, and glass fiber wedges as well as the copper for the purpose of keeping it almost totally free of outside radio interference and noise.

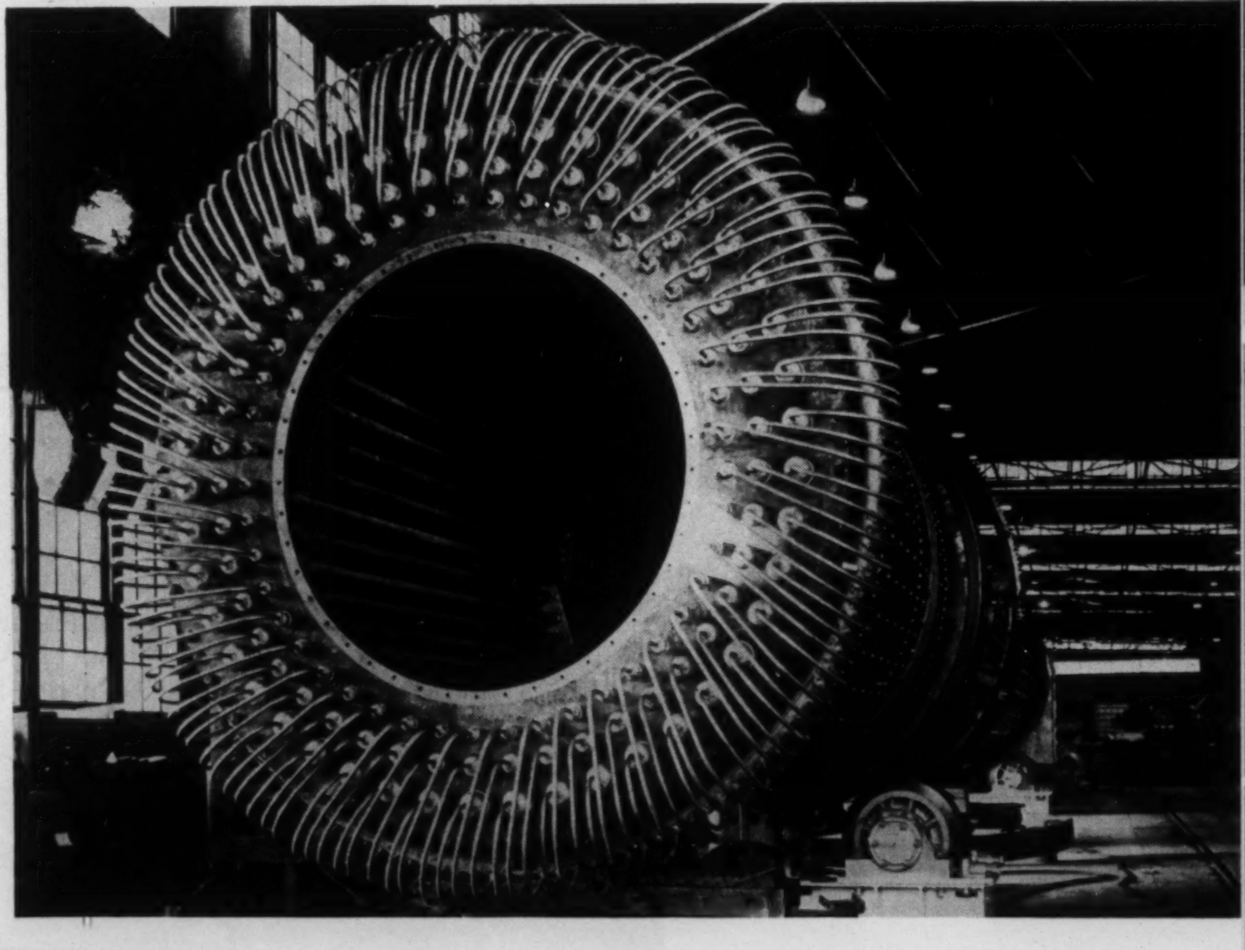
Research in the sound test building is expected to show how to reduce noise in transformers and to insure that future transformer improvements will not result in pronounced radio interference.



Aluminum Jungle The interior of this 100-ft long Louisville Steam Tube Dryer contains 35,000 lb of aluminum. Alcoa 61S plate lining, Alcoa 63S pipe and finned tube, and cast aluminum supports contribute to the 23,700 sq ft of heating surface in the dryer.

The view at right shows the feed end where the steam enters the tubes, condenses and thus provides the heat for drying. In operation, the dryers are angled slightly downward toward the discharge end. Constantly rotated, the units dry fine solids which travel the length of the dryer.

The dryer shown here in the final stages of fabrication is one of a group being manufactured by General American Transportation Corp. for a major chemical producer.

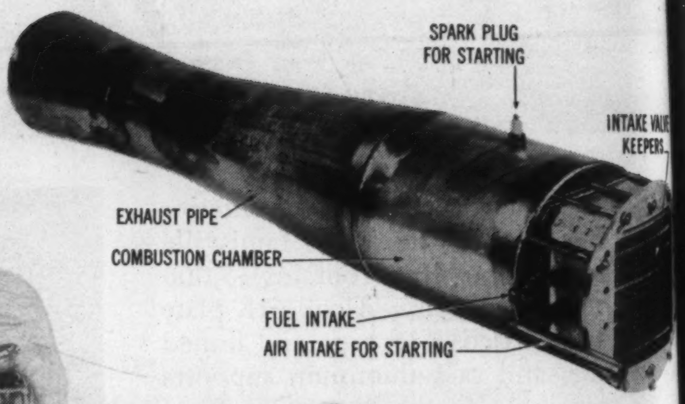


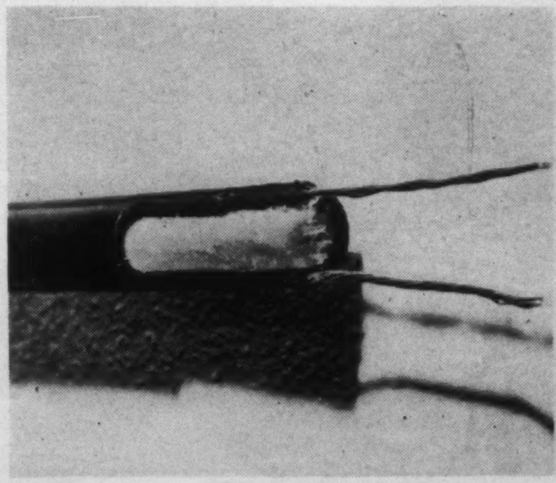
U.S. ARMY
01840

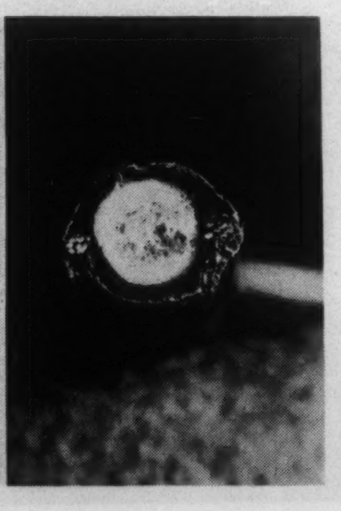
Nickel Adds Life to Pulse Jet

The incorporation of Inconel X in each of the Intake Valve Keepers of this pulse jet, redesigned by the U.S. Naval Research Lab., lengthened its service life to 200 hr. This 300% improvement was due to increased resistance to fatigue cracking during 118,000,000 openings and shuttings, plus easier formability.

The pulse jet is being used on the portable helicopter made experimentally by the American Helicopter Co. It weighs 700 lb fully loaded and will fly at speeds up to 80 mph for an hour and a half.





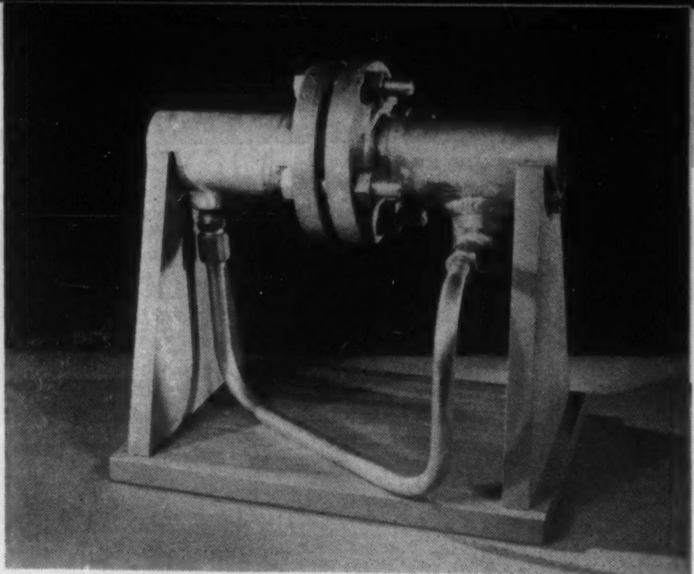


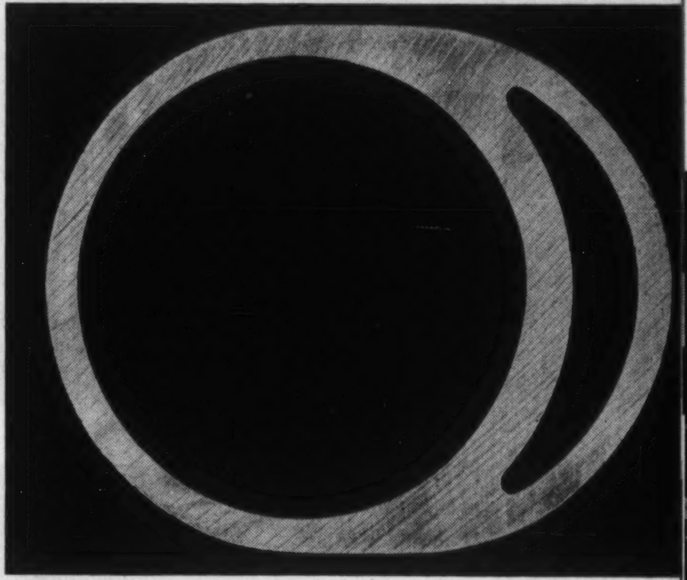
Foam Plastic Insulates TV Lead

A new lead-in wire for UHF and VHF television reception which reduces picture-distorting electrical line losses has been developed by the Belden Mfg. Co.

The wire incorporates Bakelite solid polyethylene wrapped around a core of Bakelite cellular polyethylene (M&M, Jan. 1954, p. 142). The bulge of cellular plastic between the wires instead of the flat tape of conventional television lead-ins reduces the effect of moisture, soot and dust on the surface of the wire.

The parallel conductors are annealed copper-covered steel strands with 49% greater resistance to breaking from flexing or stretching than all-copper conductors, according to the manufacturer.

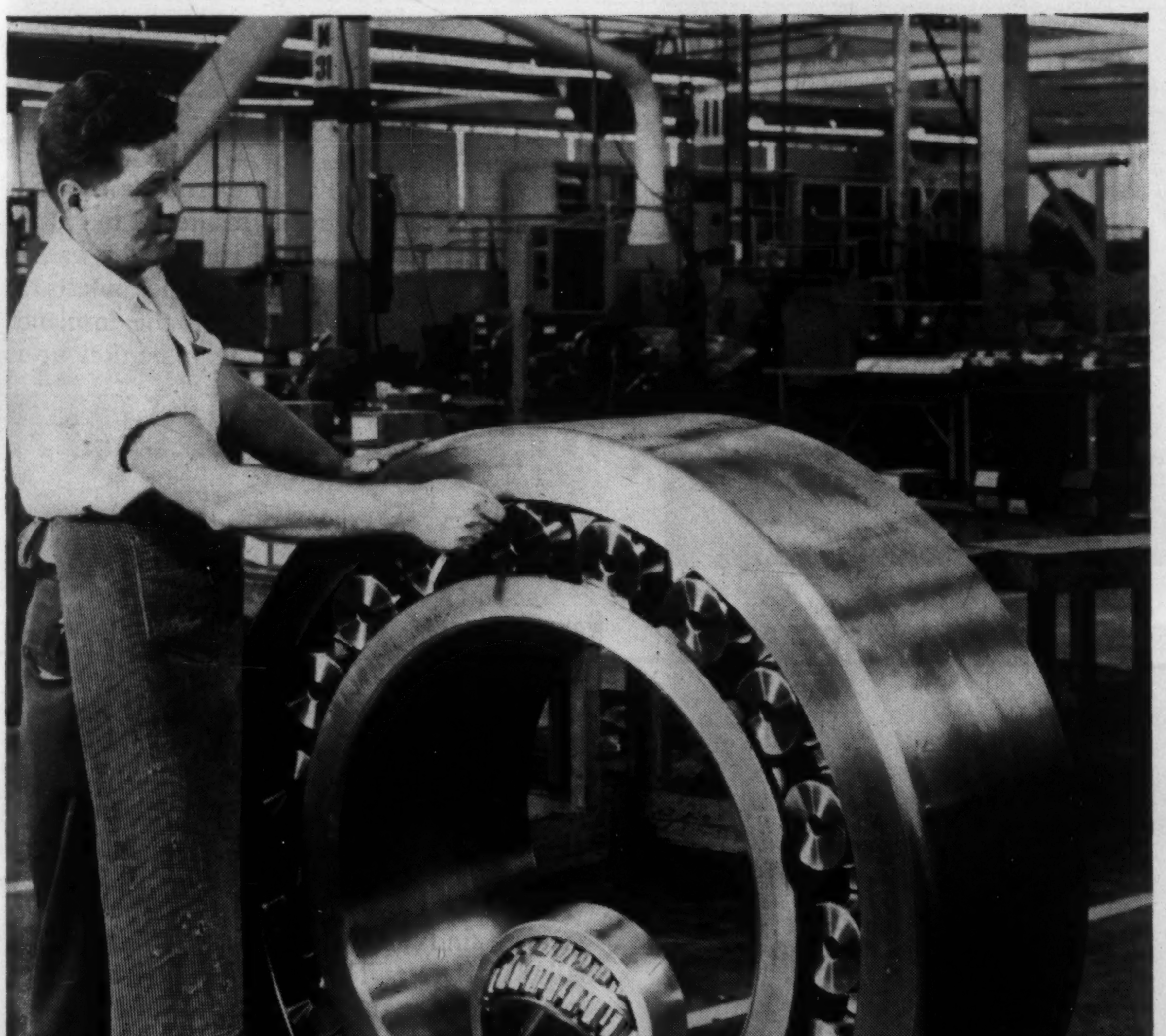




Steam Jacket Extruded on Aluminum Pipe Aluminum pipe with an integral steam jacket is now being extruded by Alcoa for use in industries which handle sluggish chemicals such as tar and pitch or trickly solutions such as ammonium nitrate. These materials require heated lines to prevent solidification or crystallization in the lines. In contrast to normal methods of heating lines by using an external steam jacket or steam tube to apply the heat, Unitrace is produced so the steam line is an integral part of the pipe.

A possible method of joining two sections of Unitrace is shown at top. An Alcoa Utilitube jumper carries the steam across the joint, allowing periodic opening of the line.

Jointly engineered by Alcoa and Hercules Powder Co., Unitrace is extruded from 3S-F aluminum alloy, and in dimensions conforms to standard 2-in. Schedule 40 pipe.



King-Size Bearing This huge bearing, with a 48-in. o.d. has just been manufactured by SKF Industries for a large 18-in. tube reducing machine developed by Tube Reducing Corp. It is shown in comparison with a bearing for one of the 2¼-in. tube reducing machines.

Made of SAE 52100 steel, the bearing is used in a roll neck operation in which the tubing is cold worked under compression by rolls that rock back and forth over the tube and mandrel to obtain the desired size, shape and finish.

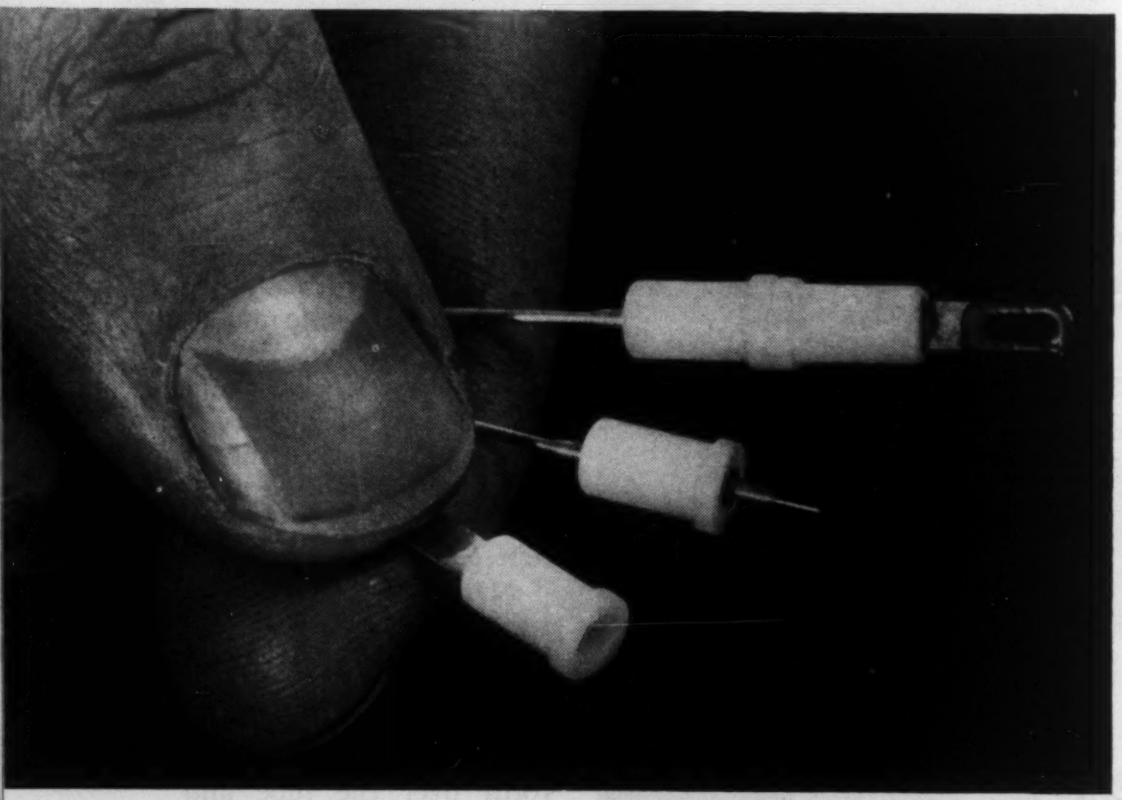
By using self-aligning bearings, the radial as well as the axial fixing of the rolls is obtained, permitting the rolls to size the finished tubing to the close tolerances required.

Materials at Work

Phenolic Roller Salts Potato Chips

The plastic roller (arrow) machined from fine weave cotton filler impregnated with phenolic resin, spreads salt on potato chips. Metal rollers used previously tended to corrode if any salt particles remained on the rollers overnight. This corrosion would impart an "off" taste to the next day's run.

The new rollers developed by Synthane Corp. are easy to clean and stay dry at all times. To offset the possibility that the phenolic might impart a taste of its own, the roller receives an extra curing period which completely neutralizes the laminate.

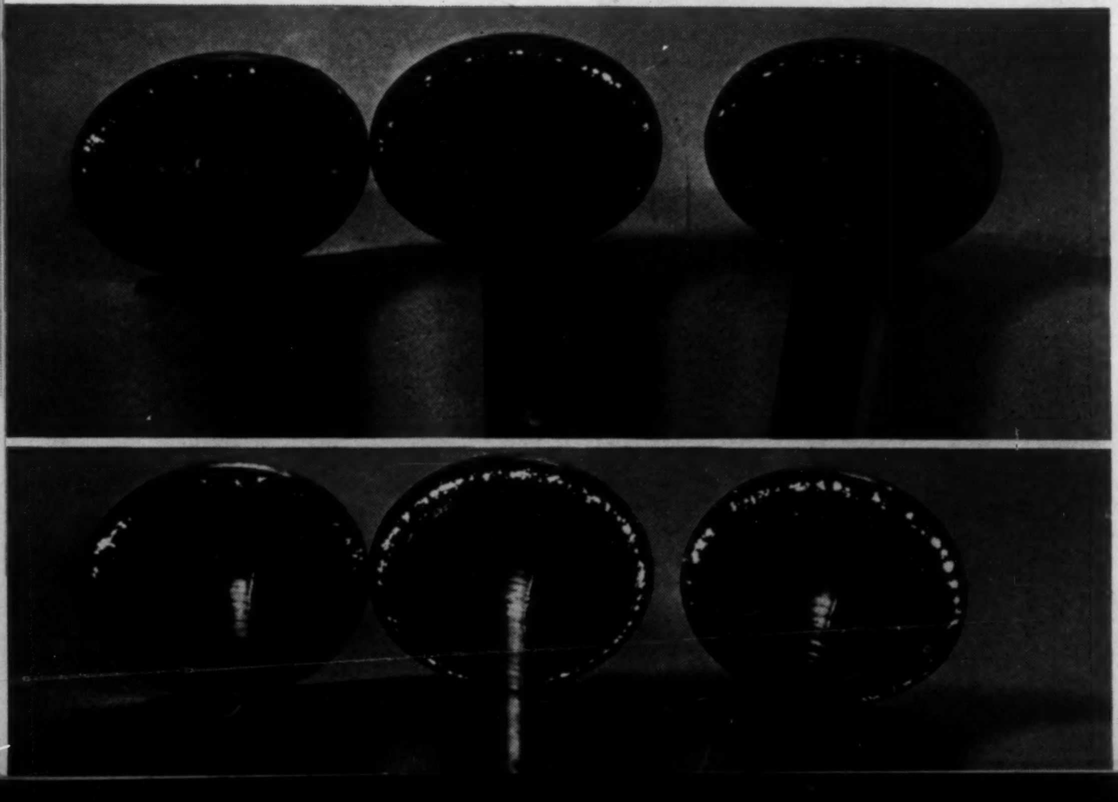


Plastics Again Aid Miniaturization

Miniature connector assemblies, consisting of feed-through plugs and contact receptacles, are being manufactured of Teflon, du Pont's fluorocarbon plastic.

Made by Sealectro Corp., the assemblies are expected to find application in electronic instruments, television and radio sets as plug-in components, such as crystal diodes, coils, and coil forms, as well as in other inter-connecting applications.

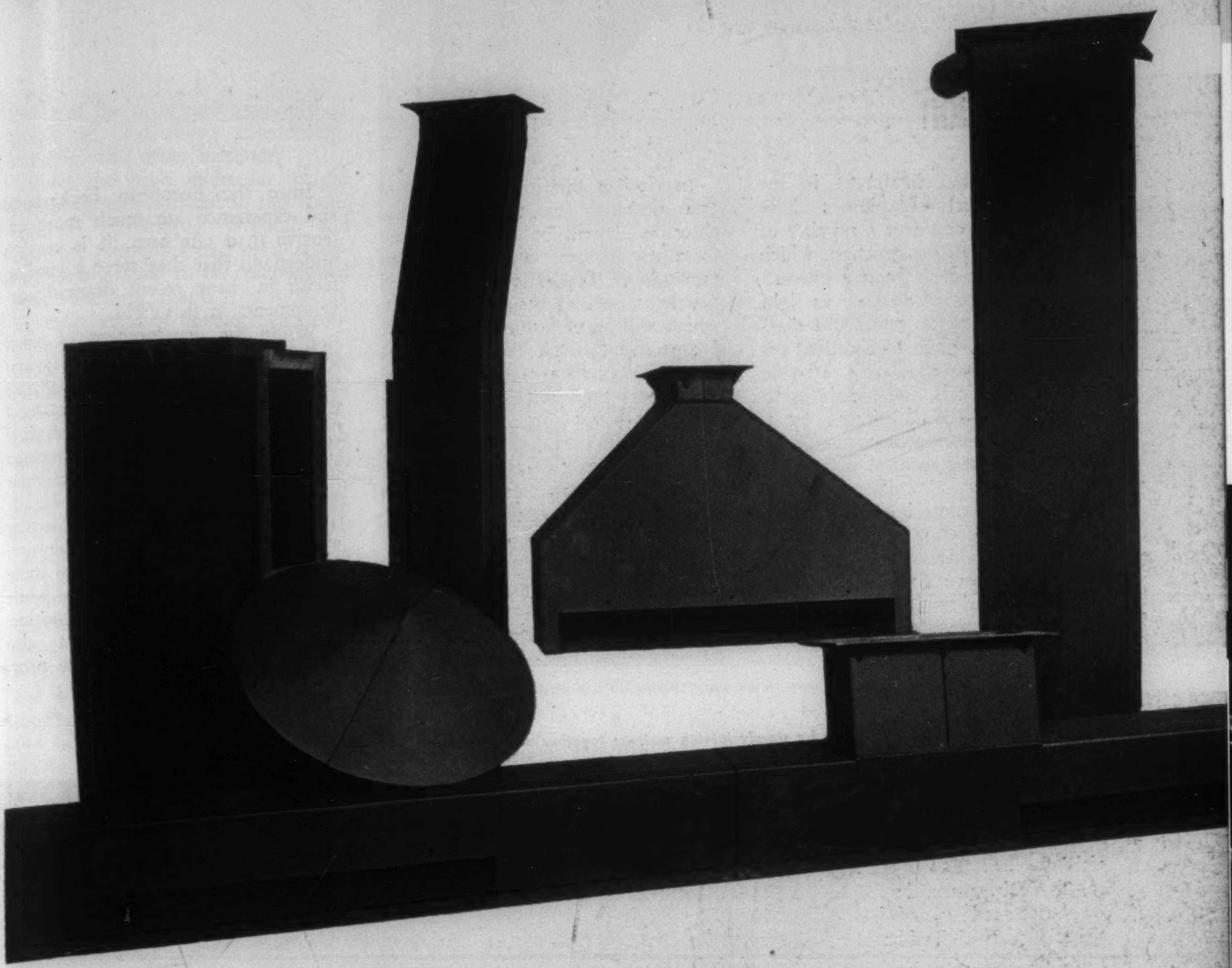
In addition to the high electrical insulating properties of the plastic, its resilience and plastic memory eliminate the need for nuts or washers and make press-fitting possible. The contacts can be soldered without damage to the insulation since Teflon can withstand temperatures up to around 500 F.



New Penetrant Speeds Inspection

These diesel valves, after refacing with high alloy welding, were okayed visually before being sent on for engineered inspection. In the bottom half of the picture the improved sensitivity of the Zyglo-Pentrex fluorescent inspection material is evident when compared with the upper half, where an older material was used.

Developed by Magnaflux Corp., the material is said to find both very tight cracks and broad, shallow defects. The emulsifier, which is not contained in the material, is applied after penetration by a separate dip. In this way, both emulsification time and washing are controlled to suit the particular part or type of defect.



Fabrication and Use of
Rigid Polyvinyl Chloride Plastics

by **J. L. HUSCHER,** Kaykor Industries, Inc.

MATERIALS & METHODS
Manual No. 105

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

JUNE 1954

Rigid polyvinyl chloride plastics, commonly referred to as PVC, is a relatively new structural material now available to the engineer and designer. It offers a wide range of excellent properties such as light weight, good corrosion resistance, and ease of fabrication. To assist the engineer in the selection and use of PVC, this Manual covers the following:

- *Physical and Chemical Properties*
- *Machining and Cutting*
- *Forming Methods*
- *Joining Methods*
- *Design Suggestions*

Introduction

● RECENT DEVELOPMENTS in the field of structural plastics have opened to the engineer a number of new materials of construction, which offer a variety of extremely interesting general properties, such as light weight, excellent electrical and thermal insulation, good to excellent resistance against attack by a wide range of chemicals, and the ability to be processed and fabricated by a series of processes previously almost unknown in the structural and equipment fields.

One of the most important materials in this group is unplasticized or rigid polyvinyl chloride, which recently has been finding a sharply increasing market in this country, while the European experiences with this material date back as far as 1937.

In view of this increasing interest and demand for rigid polyvinyl chloride, it will be attempted here to review in some detail the various methods of fabrication and related problems, such as basic design rules, which will be of interest to both the prospective fabricator and the final user of equipment fabricated from rigid polyvinyl chloride. In view of the obvious limitations, it will not be possible to discuss in full detail the various fabrication methods, but rather several alternate methods will be discussed wherever possible.

Historical Background

It should be of general interest to review briefly the development of rigid polyvinyl chloride as a material of construction.

Since the European background and experience are much more extensive than our own, it is easy to understand that they were a guiding factor in many recent domestic developments in this field.

While the development of vinyl polymers, and primarily of polyvinyl chloride progressed at a similar rate in this country and in Europe, most efforts in the utilization of polyvinyl chloride in the United States seemed to be directed on the high molecular weight polymers. As is generally true, polymers of higher molecular weight usually offer better physical and chemical properties than those of lower molecular weight, and while this is true with polyvinyl chloride, increasing molecular weight also brings about difficulties in the proc-

Rigid vinyl pipe can be laid rapidly by simply joining sections together with a special adhesive.

essing of the resin into semi-finished forms of extrusion, calendering, molding, and other methods.

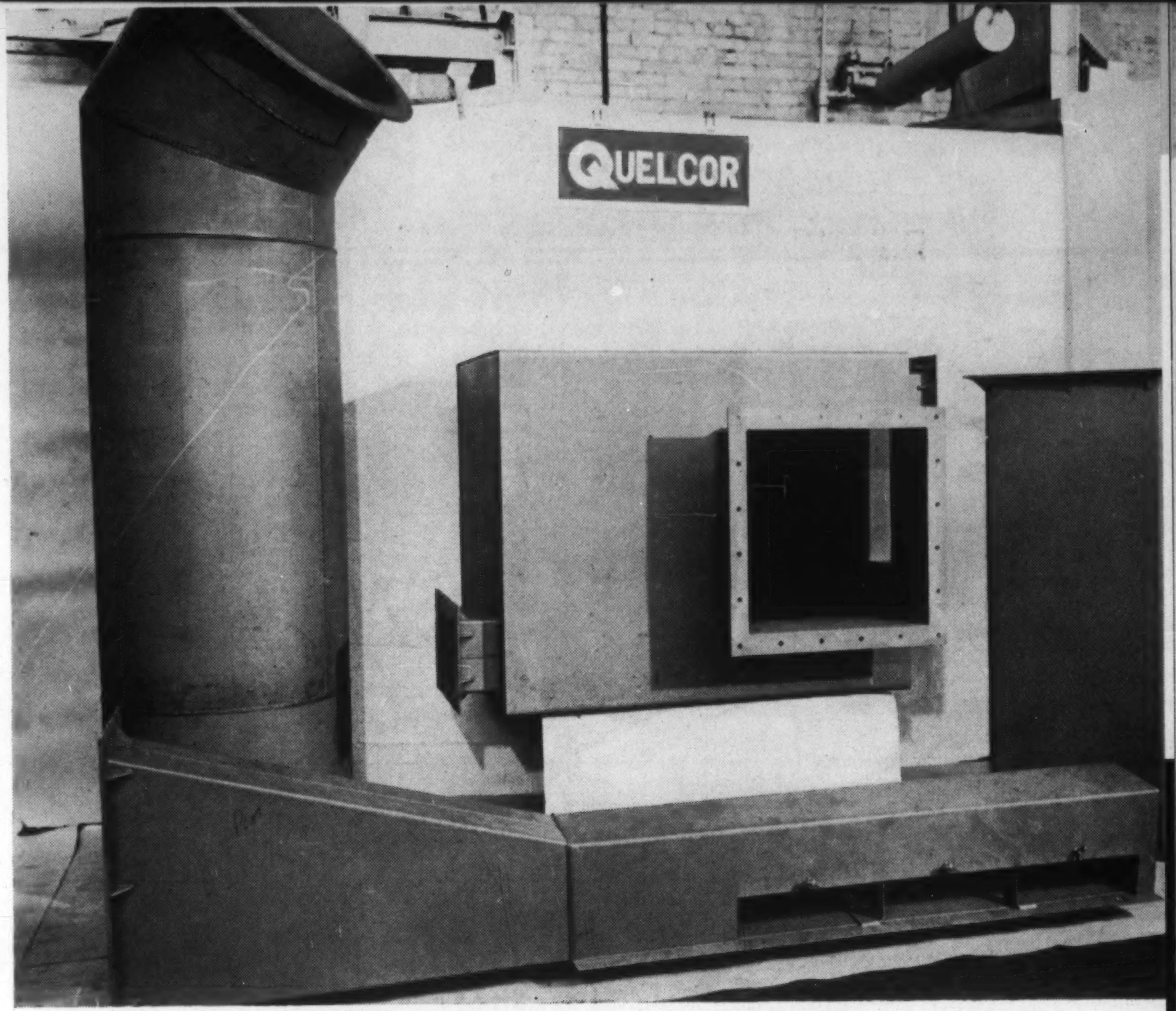
Since the high molecular weight resin originally utilized in this country—its outstanding physical and chemical properties had been recognized early—had to be compounded with softening agents (plasticizers) the main trend of developments concentrated on soft or plasticized polyvinyl chloride, its processing, fabrication, and end uses. European, and primarily German developments covered a wider range of molecular weights of vinyl polymers, and it was recognized that polymers of slightly lower molecular weight could—with only a small sacrifice in physical and chemical properties—be processed in nonplasticized form.

In the combination of the many desirable physical and chemical properties, German engineers recognized a potential material of construction, and when Germany was beset with shortages of vital alloys, processing and fabrication methods for unplasticized polyvinyl chloride were developed and improved so that parts and equipment fabricated from the material replaced in many instances those made from alloy steels and other metals. Along with this development came the necessary education of engineers, designers, and fabrication personnel which succeeded to the point where today polyvinyl chloride is a fully accepted material of construction—applied primarily where certain corrosive conditions prevail. Despite the fact that the various alloys are again in full supply in Europe, the volume of applications of unplasticized polyvinyl chloride is still increasing, proving its ability to compete successfully with various metals not only in technical but also economical respects.

When, after World War II, most of the German developments and accomplishments in the field of rigid polyvinyl chloride became known in this country, most raw material manufacturers were reluctant at first to consider the production of the types of polyvinyl chloride resin which would lend themselves to processing and fabrication in unplasticized form. By now, such resins are available on the domestic market, a fact which has contributed greatly to the recent increase in the interest in this material.

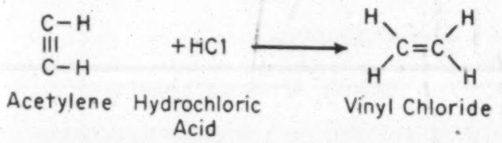
What Is Polyvinyl Chloride?

It might be of interest here to point out briefly the chemical make-up of polyvinyl chloride and its methods of manufacture.

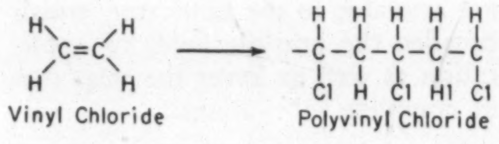


These ventilating ducts of PVC plastic carry away acid fumes from plating tanks.

The reaction of hydrochloric acid with acetylene produces vinyl chloride, which serves as monomer in the manufacture of polyvinyl chloride:



The unsaturated double bond in vinyl chloride makes possible the setting off of a chain reaction (polymerization), which is carried out under carefully controlled conditions, and the product of which is polyvinyl chloride:



In addition to the control of polymerizing conditions, the actual form in which the monomer is supplied in the process, (emulsion, suspension, solution, etc.) has a great bearing on many properties of the resulting polymer.

The molecular weight of the polymer is determined by the chain length of the product and has considerable effect on the processing characteristics of the resin. Constant improvements in polymerization techniques have made possible the production of polyvinyl chloride resins of extremely narrow molecular weight range, resulting in uniform and reproducible products made from such polymers.

While most of the processing equipment as well as processing methods and techniques of polyvinyl chloride had been developed for the plasticized compounds of polyvinyl chloride, the unplasticized material can be processed by the usual methods such as extrusion, calendering, lamination, compression and recently also injection molding at temperatures between 325 and 400 F. The processing of unplasticized polyvinyl chloride requires considerable skill and extremely close control of operating conditions to result in a high quality product.

With further respect to the processing of polyvinyl chloride it should be said that the resin itself cannot be processed as such by any of the above mentioned methods without being compounded with stabilizers and possibly other additional processing aids, such as lubricants. These stabilizers are necessary since polyvinyl chloride, when subjected to the heat necessary in the various processing methods, liberates hydrochloric acid in an autocatalytic reaction, and therefore suitable stabilizers which will both neutralize the hydrogen chloride as well as prevent formation of isolated double bonds in the resin molecule have to be incorporated into polyvinyl chloride compounds for most all applications.

Table 1—Available Forms

Sheet and Plate	Thickness Overall dimensions Colors Surface finish	0.012 to 1.000 in. From 30–48 in. width x 60–120 in. length All Dull, semi-polished, press polished
Block	Thickness Overall dimensions Colors Surface finish	Up to 4 in. Up to 20 x 20 in. All Dull, semi-polished, press polished
Pipe (NPS)	Diameters Wall thickness	From ½ to 6 in. Nom. Dia. Available in schedule 40 and schedule 80
Pipe, Tubing and Ducting	Diameters Wall thickness	From 6 to 14 in. i.d. In accordance with requirements
Pipe, Tubing and Ducting Fittings	Fabricated type	6 to 14 in. i.d.
Rod	Diameter	Up to 2 in.
Welding Rod	Diameter	3/32, 1/8, 3/16, 1/4 in.

Table 2—Fabrication Methods for Rigid Polyvinyl Chloride

Machining	Forming	Joining
Shearing	Bending	Hot gas welding
Sawing	Rolling	Friction welding
Drilling	Vacuum forming	High frequency welding
Turning	Deep drawing	Cementing
Milling		Bolting, screwing, riveting
Planing		
Routing		
Sanding		

Available Forms

A variety of semi-finished forms and sections, such as plate and pipe, are available to the fabricator, which broaden the possible fields of application as well as lower the total cost of complete fabrications.

Table 1 lists the various semi-finished products available today and gives an approximate range of sizes on which the fabricator can draw. Efforts are now being made by the Thermoplastic Structures Division of the Society for Plastics Industry, to develop specifications for rigid polyvinyl chloride sheet and plate which are to be used in the fabrication of industrial structures such as hoods, ducts, storage vessels, pipe lines and other applications.

Since this entire industry is relatively young in the United States, special sections and proprietary products, such as valves, pipe expansion joints, pumps, etc. are now becoming available on a larger scale. No doubt, the availability of such items will be greatly expanded as the need for them increases, which is best illustrated in the production and sale of the widest variety of such products in Germany today, where rigid polyvinyl chloride has reached an extremely high level of use in various industrial fields.

Forming and Fabrication

Probably of greater importance than the chemical resistance and the low specific gravity, is the ease with which these plastics can be machined, formed, and joined by a wide variety of fabrication methods. The methods are either identical to those used with most common construction materials or which represent slight modifications of such standard methods to allow for or take advantage of some of the particular properties of rigid polyvinyl chloride.

Table 2 lists the various fabrication methods to which rigid polyvinyl chloride lends itself, and in later sections it will be attempted to furnish a more detailed account of the fabrication methods, and whereever possible, alternate procedures will be indicated.

Physical and Chemical Properties

It should be pointed out that the properties discussed in this section as well as the fabrication methods described later apply primarily to rigid or unplasticized polyvinyl chloride, which is compounded of straight polyvinyl chloride resin, stabilizers, and possibly small quantities of lubricating and pigmenting agents.

Recently, modifications of the material have been introduced—primarily in the pipe field—because it was felt imperative to raise the low notch sensitivity of unplasticized polyvinyl chloride to make the material successful in applications where notch effects (such as of pipe threads) as well as generally rough handling would be encountered. These "modified" or "high-impact" polyvinyl chlorides are achieved by introduction of copolymers and other modifying agents which tend to increase the impact strength of the material, but on the other hand reduce greatly the tensile strength, flexural strength, and primarily the outstanding chemical resistance inherent in the unplasticized and unmodified material.

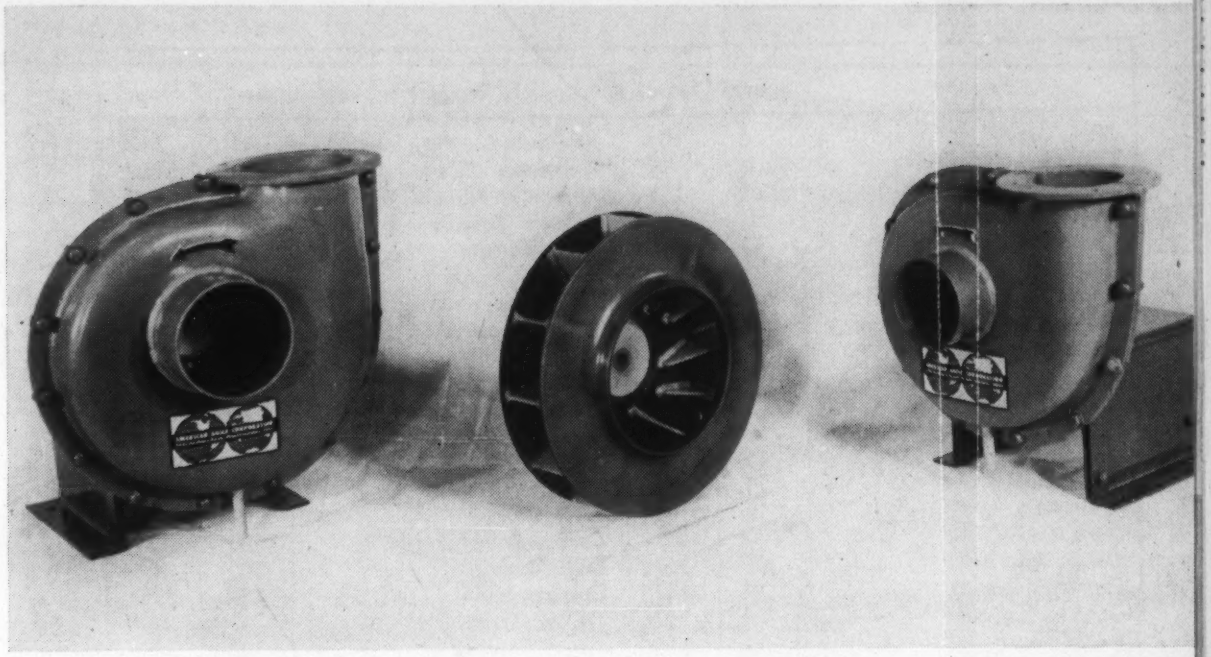
Therefore to avoid confusion, the following discussion shall be limited to rigid or unplasticized polyvinyl chloride, while information on modified or high-impact polyvinyl chlorides should be supplied by the individual manufacturer of such materials, since quite a wide range of properties, which would be difficult to tabulate, can be achieved through this type of compounding.

Table 3 lists the most important physical properties of rigid polyvinyl chloride at room temperature.

Because plastics, particularly thermoplastics such as polyvinyl chloride, are subject to considerable creep under continuous loads, strength values as shown in Table 3 must be specified to apply to short-term (generally 3-min loading) tests. Various strength values decrease to a certain level as the loading-period increases. tests carried out by the Firestone Plastics Co., to determine the tensile strength and related values under long-term loads have shown that with increasing loading-periods, the ultimate tensile strength decreases to a minimum value of 5500 psi (at room temperature) at or below which no further change is expected to occur. These findings show considerably higher values than those reported by German producers, and seem to be due primarily to some basic differences in the constitution of the polymers used in the two countries.

The short-term strength values for the various types of loads (compression, flexure, etc.) are in a fixed ratio to the tensile strength, as is the case of metals as well as other plastics, and since they are greater than the tensile strength, and compressing loading is generally uneffective, fractures and cracks will usually occur in cross-sections under tension.

The comparative values of notched and unnotched impact strength will be of greatest interest to the designer and fabricator. The rather low value for notched impact strength might be the cause for doubt in the mind of some construction engineers. It should be pointed out though, that the purpose of a notched impact strength test is not the determination of absolute values, since test conditions can never exactly duplicate actual operating conditions for the material in use. Rather, it means to determine sub-par quality caused by production methods which prevent the reaching of certain standard values established for the particular material. It is the job of the fabricator of polyvinyl chloride equipment and apparatus to take into account these peculiarities of the material, and further attention to this point will be given during the discussion of basic design rules.



Fully fabricated fume exhaust fans and close-up of impeller made of PVC plastic.

Since the uses of polyvinyl chloride as material of construction cover a multitude of applications ranging in temperature from 20 to about 170 F, the changes of certain properties with temperature are illustrated in Fig 2. Particular reference to some of these properties will be made during the discussion of the forming methods for the plastics.

With respect to the chemical resistance of rigid polyvinyl chloride, the principle form of corrosive attack consists in the penetration of the corrosive liquid or gas into the interior of the material rather than a chemical reaction with the surface. Rigid polyvinyl chloride, like most other plastic materials, will show a weight increase rather than the weight loss experienced by metals undergoing corrosion, and this weight increase is directly related to a volume increase.

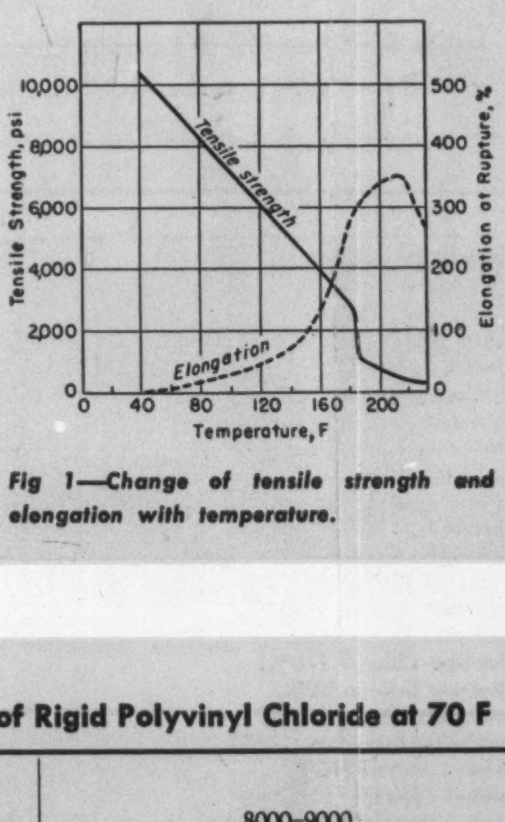


Fig 1—Change of tensile strength and elongation with temperature.

Table 3—Physical Properties of Rigid Polyvinyl Chloride at 70 F

MECHANICAL PROPERTIES	
Ultimate Tensile Strength, psi	8000–9000
Compressive Strength, psi	10,000–11,000
Impact Strength, Izod (unnotched), ft-lb/in.	40–60
Impact Strength, Izod (notched), ft-lb/in.	0.5–0.8
Modulus of Elasticity (flexure), psi	500,000
Hardness, Rockwell R	120
Specific Gravity	1.40
THERMAL PROPERTIES	
Thermal Conductivity, Btu/ft^2/sec/F/in.	2.8 x 10^{-4}
Coefficient of Linear Expansion, per F	4.5 x 10^{-5}
Heat Distortion Point, F (at 66 psi)	165–167 F
Specific Heat	0.32
Flame Resistance	Self-extinguishing
ELECTRICAL PROPERTIES	
Dielectric Strength, v/mil (78.8 F)	1200–1300
Dielectric Constant (at 10^6 cpm)	3.0–3.2
Volume Resistivity, ohm/cm	10^{15}
Power Factor	0.02

Table 4—Chemical Resistance of Rigid Polyvinyl Chloride

This table lists a number of chemicals at various concentrations, and indicates the maximum operating temperature at which rigid polyvinyl chloride can be satisfactorily used in contact with these chemicals.

Reagent	Contr.	Max F	Reagent	Contr.	Max F
Acetic Acid	10	100	Aluminum Chloride	all	160
Acetic Acid	100	75	Ammonium Chloride	all	160
Benzoic Acid	all	150	Ammonium Nitrate	all	160
Boric Acid	all	150	Calcium Chloride	all	160
Chromic Acid	50	165	Nickel Sulfate	all	160
Citric Acid	25	165	Pot. Dichromate	50	140
Formic Acid	100	125	Pot. Permanganate	25	125
Hydrobromic Acid	all	160	Silver Nitrate	all	160
Hydrochloric Acid	25	160	Sodium Bisulfite	all	160
Hydrochloric Acid	100	150	Sodium Sulfide	all	160
Hydrofluoric Acid	25	125	Stannous Chloride	25	125
Hydrofluoric Acid	50	70	Zinc Chloride	all	160
Lactic Acid	25	160			
Nitric Acid	25	160	Acetaladehyde	50	70
Nitric Acid	50	160	Butyl Alcohol	100	160
Nitric Acid	100	100	Carbon Tetrachloride	100	125
Oxalic Acid	all	160	Ethyl Alcohol	100	100
Perchloric Acid	20	100	Formaldehyde	50	160
Phosphoric Acid	all	160	Glycerine	100	160
Sulfuric Acid	30	130	Methyl Alcohol	100	125
Sulfuric Acid	50	160			
Sulfuric Acid	80	160	Alums	100	160
Sulfuric Acid	100	130	Chlorine gas, dry	10	100
			Hydrogen Peroxide	30	160
Ammonium Hydroxide	all	160	Ozone	100	100
Calcium Hydroxide	all	160	Sea Water	100	100
Potassium Hydroxide	all	160	Beer	100	125
Sodium Hydroxide	all	160	Wine	100	160

NOTE:
Rigid polyvinyl chloride is not recommended for use with acetone, ketones, ethers, esters, aromatic hydrocarbons and chlorinated hydrocarbons.

Table 5—Changes of Certain Physical Properties of Rigid Polyvinyl Chloride After Chemical Immersions at 75 F for 12 Months

	Tensile Str, psi	Flexural Modulus, psi	Heat Distortion, F
Warehouse Aged Sheet	8500	540,000	167.0
Acetic Acid (10%)	8200	560,000	165.2
Acetic Acid (Conc.)	8300	560,000	165.2
Citric Acid (10%)	8100	550,000	165.2
Hydrochloric Acid (10%)	8400	540,000	165.2
Hydrochloric Acid (Conc.)	9000	580,000	163.4
Nitric Acid (10%)	8200	540,000	165.2
Nitric Acid (Conc.)	9000	570,000	165.2
Sulfuric Acid (10%)	8100	570,000	165.2
Sulfuric Acid (Conc.)	8200	610,000	167.0
Potassium Hydroxide (10%)	8300	540,000	165.2
Potassium Hydroxide (50%)	8700	570,000	167.0
Aluminum Chloride (10%)	8300	540,000	167.0
Aluminum Sulfate (20%)	8500	550,000	165.2
Ammonium Nitrate (10%)	8600	530,000	165.2
Ammonium Persulfate (10%)	8400	550,000	165.2
Calcium Acetate (10%)	8500	540,000	165.2
Calcium Chloride (10%)	8500	550,000	167.0
Calcium Hypochlorite (Sat'd.)	8600	540,000	165.2
Cupric Sulfate (10%)	8500	540,000	163.4
Ferric Chloride (10%)	8500	540,000	167.0
Hydrogen Peroxide (26%)	8600	530,000	165.2
Potassium Dichromate (10%)	8600	550,000	165.2
Sodium Nitrate (10%)	7700	550,000	165.2
Sodium Sulfite (10%)	8300	520,000	165.2
Zinc Chloride (10%)	8700	527,000	163.4
Distilled Water	8100	550,000	165.2
Butanol	8900	570,000	167.0
Carbon Tetrachloride	8600	540,000	165.2
Diethylene Glycol	8600	560,000	167.0
Kerosene	8600	570,000	167.0
Methanol	8000	520,000	150.8

Unplasticized polyvinyl chloride offers exceptional resistance against a great number of corrosive media, which in many cases surpasses that of high grade steels and alloys. This excellent resistance is due to the fact that swelling caused by aqueous reagents is low, and because a chemical reaction between polyvinyl chloride and corrosive media takes place only in a few border cases. While such values do form the basis for the general tables of chemical resistance such as Table 4 and 5, the amount of swelling and weight increase cannot be accepted as positive criteria to determine the resistance of rigid polyvinyl chloride towards a given corrosive medium.

The material resists attack by most mineral acids (including nitric and sulfuric acids), bases, and salts through a broad range of concentrations, with a maximum temperature of up to 165 F at which it can be satisfactorily employed. Maximum temperature varies with the concentration of the corrosive medium and Table 4 points out some of these limits. Rigid polyvinyl chloride is not recommended for use with acetone, ketones, ethers, esters, aromatic hydrocarbons, and chlorinated hydrocarbons.

Both fabricators and ultimate consumers must realize that it is impossible to publish all the required data, and also that frequently mixtures of two or more chemicals are encountered, for which special exposure tests must be carried out or the material manufacturer be consulted as to their previous experience under similar conditions.

Since the prime interest in this article is devoted to the actual fabrication procedures and basic design factors, the effect of a number of chemicals on tensile strength, flexural modulus and heat-distortion temperature, which are of prime importance to the fabricator, are shown in Table 5.

It cannot be stressed sufficiently that information such as contained in Tables 4 and 5 can serve as a basic guide only, since the data cannot necessarily be applied to all operating conditions.

It is important that the fabricator secure complete information on the composition and concentration of corrosive media to which the rigid polyvinyl chloride will be exposed. Even small impurities of aromatic or halogenated aliphatic hydrocarbons can have damaging effects on long term exposures. Equally important is the information or determination of temperature limits, and therefore it frequently becomes highly advisable to carry out additional material tests under actual operating conditions to ascertain the ability of the plastics to perform satisfactorily in a specific corrosive environment.

The proper performance of unplasticized polyvinyl chloride as a material of construction does not depend solely on its resistance toward a given chemical or mixture of chemicals. The fabricator must be fully acquainted with its chemical resistance, but must take into account the mechanical requirements of such an installation, and both of these factors are predicated by a high degree of workmanship in the actual fabrication.

The combination of excellent chemical and physical properties with its ability to be fabricated by methods identical or similar to those employed with metals, is the main reason for the intense interest by equipment and apparatus designers, fabricators, and ultimate users alike, and these materials are also finding such ready acceptance in many industrial fields of application.

Machining and Cutting

Rigid polyvinyl chloride is machinable with equipment and by methods generally employed with steel, light metals, or wood. In all machining operations it must be remembered that the material is a poor conductor of heat and being a thermoplastic it will tend to soften and smear at elevated temperatures. Therefore, proper cooling must be provided for in order to achieve maximum efficiency in any given machining operation. It is also of importance to point out, that if elevated temperatures are allowed to be reached during such machining processes, they will cause a partial chemical decomposition of the plastics at these points, accompanied by the liberation of traces of hydrochloric acid, which is easily detected by its odor and by its coloration as well as dulling of cutting tool edges. Consideration must be given to the high notch sensitivity of rigid polyvinyl chloride during the various machining processes. Sharp notches and deep grooves must therefore be avoided both in the design of any fabricated product as well as during the actual fabrication work.

Both high speed steel as well as carbon steel machining tools can be employed at approximate speed indicated in Table 6 without a dulling effect on the cutting edges of these tools.

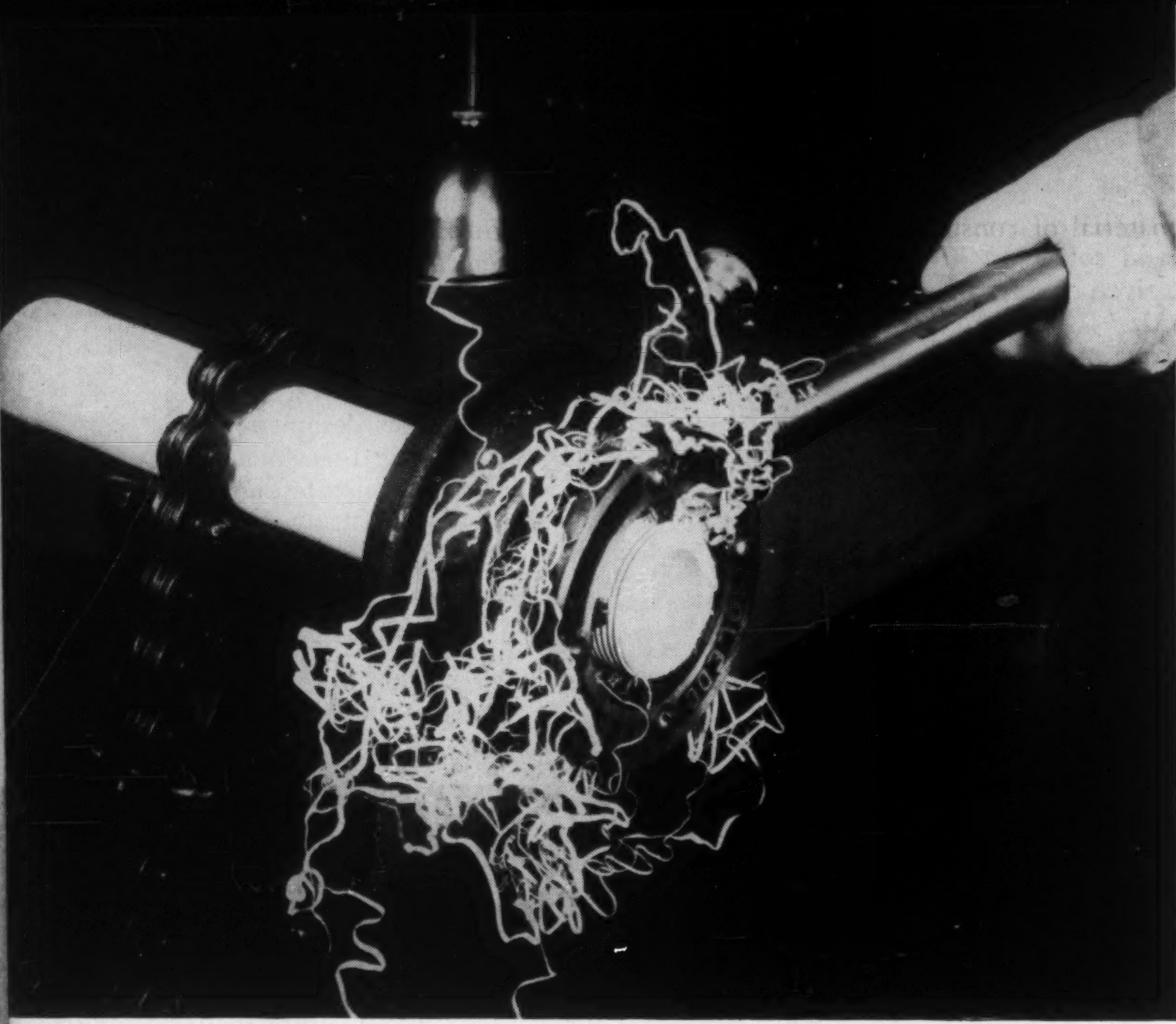
Shearing

Rigid polyvinyl chloride calendered sheeting and laminates up to about 1/16-in. thickness can be cut with standard hand-operated bench-type shears. It is important that there should be no play in the shear and also that the plate be fully supported and the shearing take place in one continuous uniform motion, otherwise chipping and non-uniform edges will result. Thicknesses in excess of

Rods of rigid polyvinyl chloride can be machined to tolerances as close as those maintained in machining steel.

Table 6—Machining Speeds for Rigid Polyvinyl Chloride

	Cutting Speed, Feet/Min.	Feed, In./Rev.
Turning	1000–3000	0.120–0.200 in.
Milling	Up to 3000	0.120 in.
Planing	Top speed of equipment	Depending on rigidity of material
Drilling	Up to 450	0.040–0.200 in.
Sawing—Circular Saw	6000	
Band Saw	3600	Hand pressure



Extruded PVC piping is being threaded with standard pipe dies.

1/16 in. are difficult to shear, although some work on heavier sections using power shears has been carried out successfully.

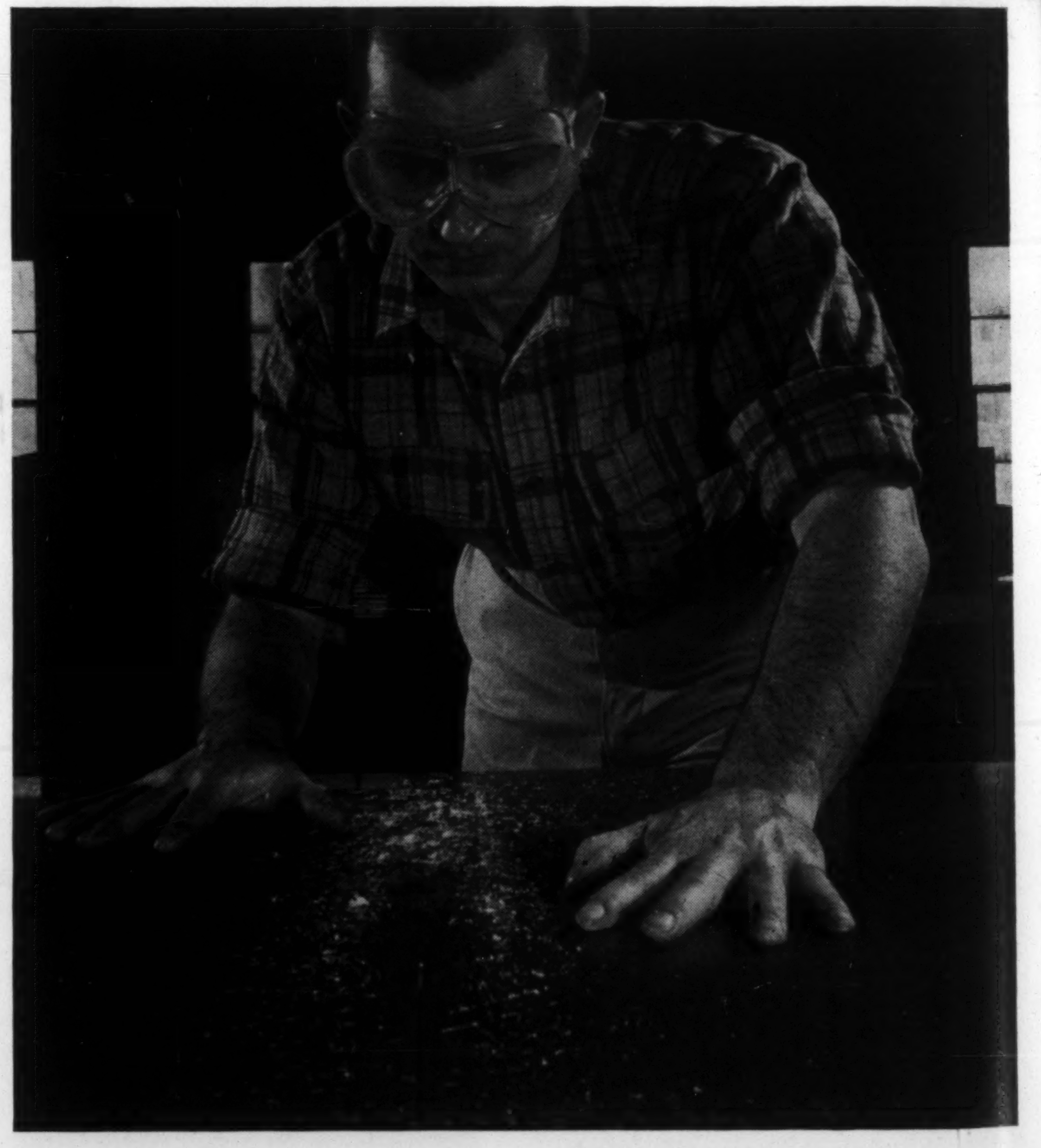
Sawing

For the sawing of rigid polyvinyl chloride, both circular (hand or bench type) as well as band saws are perfectly suitable. Saw blades should have approximately eight teeth per inch, be of the hollow ground type, and have a maximum set of about 0.025 in.

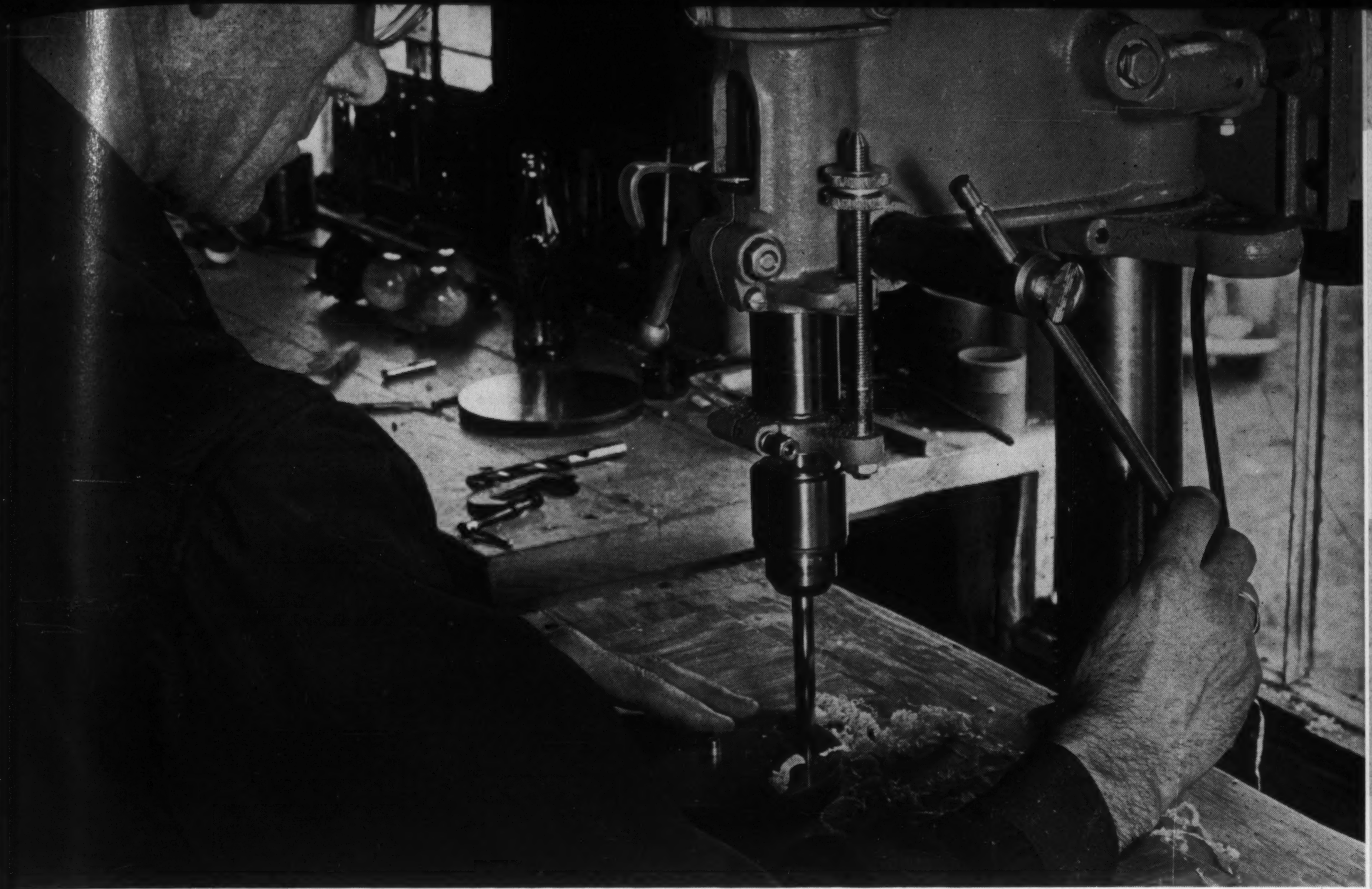
Electrically operating keyhole saws, operating with from 2400 to 4000 strokes per min are of greatest value in the sawing of intricate and irregular contours, cutting of pipe, and for the general use in the field installation work. It is extremely important that during sawing of rigid polyvinyl chloride sections, the entire section be fully supported and that hand pressure be maintained on the section during this operation, because the low notch-sensitivity can lead to cracking of the entire sheet or pipe, or to chipped and shattered cutting edges. The saw blade speed and the rate of feed is determined solely by the size and section thickness involved. It is sometimes difficult to provide effective cooling of the material. A jet of compressed air is the most efficient method of cooling. Saw dust and chips should be carefully removed from the saw cuts, since overheated chips which are not removed may impart a taste to foods and beverages which have come in contact with them on certain fabrications.

Drilling

Rigid polyvinyl chloride can be drilled with standard hand or bench drill presses using standard twist drills or any other convenient type of drill. Again, particular care must be given to efficient cooling and chip removal, since otherwise the production of truly round holes becomes extremely difficult. Also, since the material has a considerable greater thermal expansion than metallic materials, it will be necessary to oversize any particular hole, if calibrated hole sizes are required. Holes with diameters of more than 1 in. should be produced with hole saws at cutting speed as shown under lathe-turning speeds.



Rigid polyvinyl chloride sheets are easily cut on a power saw.



Rigid polyvinyl chloride can be worked on a drill press to same tolerances as metals.

Turning and Milling

Rods, tubes, and plates of rigid polyvinyl chloride can be turned without difficulty on standard lathes. Turning speeds and cutting tools correspond to those used on light metals and generally cutting speeds between 2000 and 3000 ft per min are recommended. For both turning as well as milling operations it is important that chips be quickly removed so that the frictional heat generated during machining can easily be conducted away from the work piece. Chip removal is of greatest importance in the cutting of threads.

Planing is not often employed on these plastics, but if necessary, the tools and equipment used in the planing of wood will prove satisfactory.

Sanding and Routing

Sanding and routing are primarily of importance in the preparation of edges and joints—and welded joints in particular—where uniform bevelled edges are a prerequisite for good workmanship and sound fabrication. Both belt or disk sanders are suitable for the various sanding operations which should be carried out dry. Extensive pressure of the work piece against the sanding surface should be avoided, since it will cause clogging of the abrasive due to overheating and softening of the plastics.

Forming Methods

For a better understanding of the forming methods to be described in this section, a more detailed discussion of the behavior of thermoplastic materials—and rigid polyvinyl chloride in particular—at elevated temperatures should be helpful. As is shown in Fig 2, rigid polyvinyl chloride, which is completely rigid at room temperature will soften to a certain extent after exceeding a certain temperature limit (185 F). The tensile strength decreases with increasing temperature along a straight line and at about 185 F a sudden reduction in strength occurs decreasing to about zero at approximately 360 F (See Fig 1). While at 185 F, rigid polyvinyl chloride changes from rigid to a rubbery, highly elastic state, the elongation at rupture increases gradually at first, then at a much faster rate and finally reaches a maximum value at about 200 F. At temperatures in excess of 200 F, this value decreases rapidly.

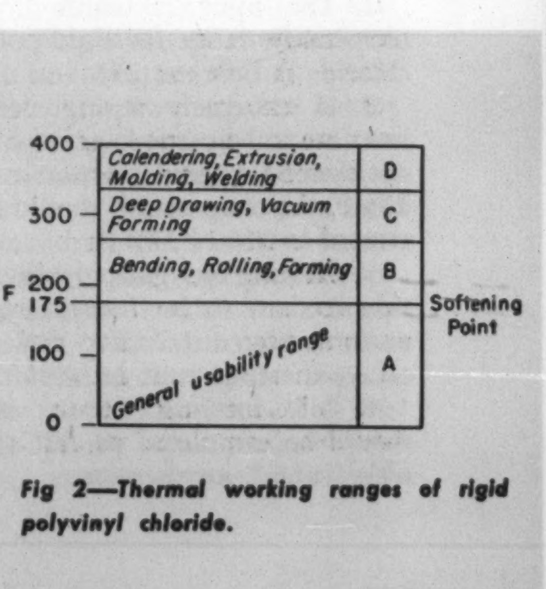


Fig 2—Thermal working ranges of rigid polyvinyl chloride.

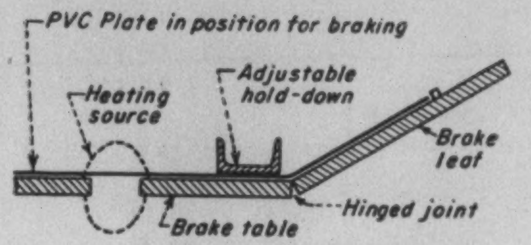

PVC Plate in position for braking
Heating source
Adjustable hold-down
Brake leaf
Hinged joint
Brake table

Fig 3—General brake-bending arrangement for plate of rigid polyvinyl chloride.

At temperatures in excess of 340 F, only extremely small elongations are possible in view of the practically nonexistent tensile strength and at temperatures between 340 and 400 F, thermoplastic deformations of rigid polyvinyl chloride are carried out under pressure (extrusion, calendering, molding, etc.) Temperatures in excess of 400 F lead to decomposition and cannot be employed in the processing and forming of polyvinyl chloride.

When the material is heated to the temperature range B shown in Fig 2, it is possible to form various semifinished sections, and to maintain the obtained form by cooling below the softening point (185 F). The new forms, which set through cooling, have a tendency to return to their original shape if the temperature is elevated above the softening point again, and this return to its original form is more pronounced when the temperature is more elevated. Because of this tendency to return under the influence of heat, any forming operation has to be carried out without interruption, since intermediate warming, such as is the practice in the drawing of steel, is not tolerable. On the other hand, the forming and return to its original shape can be repeated at will.

Therefore the following basic rules must be observed in any forming operation described in greater detail below:

1. The most favorable forming temperature range for rigid polyvinyl chloride is between 215 and 260 F;
2. If extremely strong deformations are to be carried out which cannot succeed without fracture at about 235 F, the temperature should be decreased to 210 to 225 F;
3. Heating of rigid polyvinyl chloride sections to be formed requires uniform heat distribution and all local overheating must be avoided;
4. All forming, once started, should be completed as fast as possible without interruption;
5. As soon as the actual forming operation is completed, immediate cooling to below the softening temperature should follow; this is one of the most important rules for forming of rigid polyvinyl chloride, water or compressed air should be used for rapid cooling.

In heating sheets, plates, and other forms for forming, it must be remembered that this material is a poor conductor of heat, and therefore the absorption of heat takes place at an extremely slow rate, particularly when working with heavy plate thicknesses. Since thorough and even heat penetration into the material is extremely important, properly controlled heating equipment must be provided to carry out high quality forming work.

Several methods of heating plates and sheets are possible:

1. Since polyvinyl chloride is nonflammable, the use of an open gas flame is possible, but the danger of surface burning as well as the problem of uniform heat distribution limit this method to small applications only.
2. The use of infra-red heat sources is quite practical, particularly for bending of plates, as will be seen later, while the use of infra-red heat for larger areas is more difficult.
3. The most suitable method for heating of polyvinyl chloride sheets and plates to the forming temperature consists in a hot air atmosphere, which permits even and thorough heat penetration into the material and leads to excellent and easily controlled forming conditions. A hot air atmosphere must provide a temperature of 190 to 260 F, and it is advisable to arrange the heating chamber or oven so as to maintain the plates in a horizontal, fully supported, position while bringing the material up to required forming temperature.

The use of the above described methods is described in greater detail below as they apply to the individual forming processes.

Bending of Plate and Sheet

In the bending of plate and sheet it is necessary that the area adjacent to the proposed bending line be heated to a temperature of about 230 to 260 F, and it is of importance that this area be restricted to a width of about 5 to 6 times the material thickness, which insures excellent control over the bending radius. It

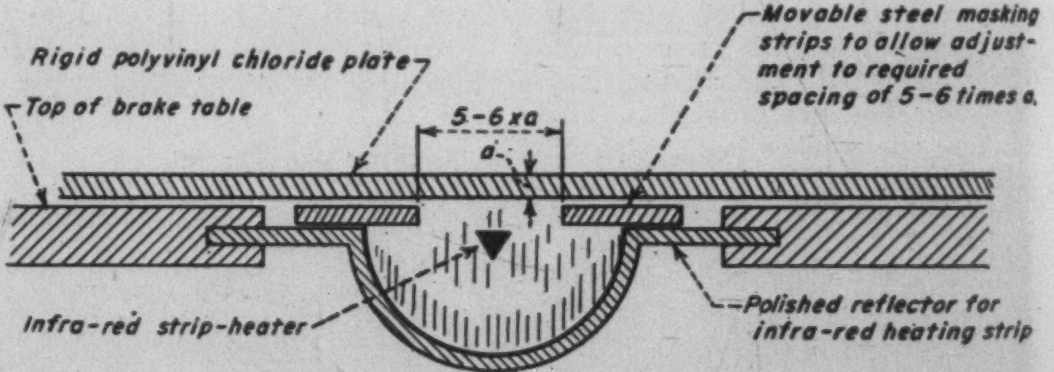

Rigid polyvinyl chloride plate
Top of brake table
5-6 x a
a
Movable steel masking strips to allow adjustment to required spacing of 5-6 times a.
Infra-red strip-heater
Polished reflector for infra-red heating strip

Fig 4—Schematic view of heating arrangement for bending brake using infra-red strip heaters.

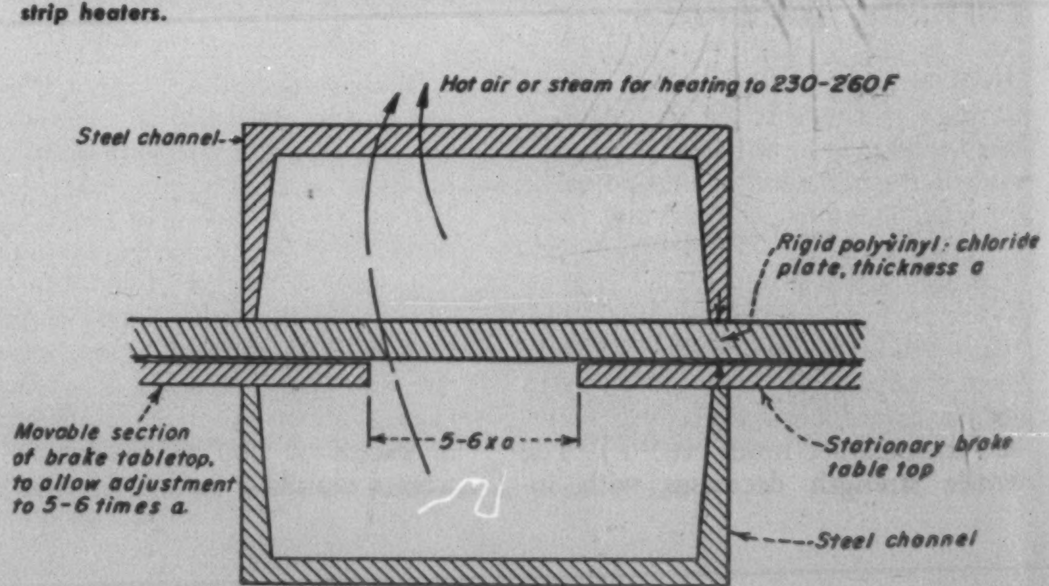

Hot air or steam for heating to 230-260 F
Steel channel
Rigid polyvinyl chloride plate, thickness a
5-6 x a
Movable section of brake tabletop, to allow adjustment to 5-6 times a.
Stationary brake table top
Steel channel

Fig 5—Schematic view of heating arrangement for bending brake using heated air or steam.

should be kept in mind that the need for power to bend rigid polyvinyl chloride plate is practically nil, since the area to be bent is brought into a highly elastic state, and therefore it is not necessary to resort to metal brakes or similar equipment. A simple arrangement for bending is shown in Fig 3 which can be built, keeping in mind though, that proper alignment is imperative. To obtain the locally heated zone, several methods are possible, two of which of the most efficient are shown in Fig 4 and 5 The method employing infra-red heating elements with a reflector is the most positive one, since a quick penetrating and uniform heat over extended lengths of bend is obtained, and adjustment and control of this heat for the various plate thicknesses is achieved through the use of a rheostat timing switch. As can be seen in Fig 4, the heated width can easily be controlled by the use of masking strips, so that with one standard, commercially available, heating element of this type, plate up to ¾-in. thickness can be bent.

The use of channels with hot air or steam, shown in Fig 5, is more intricate, since it is more difficult to obtain uniformity of temperature. This method was originally developed in Germany, but with the availability of infra-red elements has lost many of its uses.

The need of bending equipment in the fabrication shop is obvious. While the hot-gas welding process discussed further on is a great factor in the development of rigid polyvinyl chloride as structural material, both economic as well as technical advantages of bending of corners over welding of corners make the availability of such equipment a necessity.

Forming of Cylindrical Sections

Rolling as applied to the production of cylindrical sections in sheet metal fabrication has not been successfully employed with rigid polyvinyl chloride. While the principle of sheet metal rolling involves a permanent deformation by exceeding the yield point of the metal, it would require the deformation of rigid polyvinyl chloride at a temperature in range B in Fig 2, and also that this temperature be decreased to below the softening point immediately upon leaving the forming rolls. Poor heat conductivity of the material and the impossibility of obtaining such immediate and exact cooling make this system of rolling rather difficult, although several projects are in progress to overcome the various difficulties.

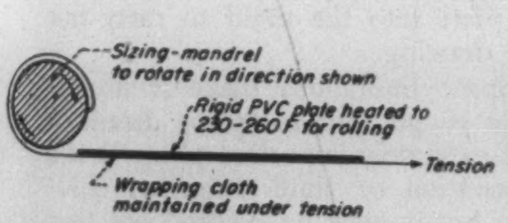


Fig 6 (above)—Principle of "cloth-wrapping" method for forming of cylindrical sections of rigid polyvinyl chloride plate.

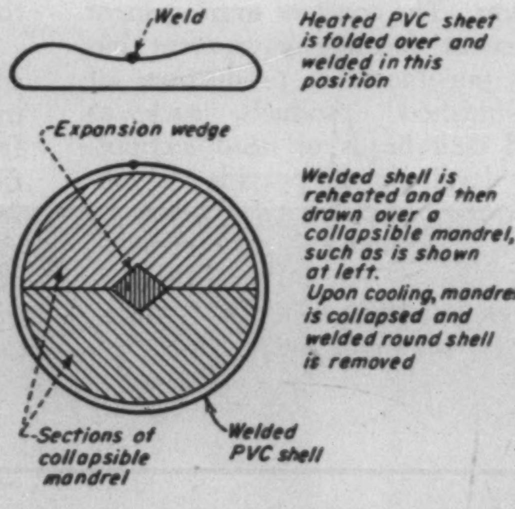
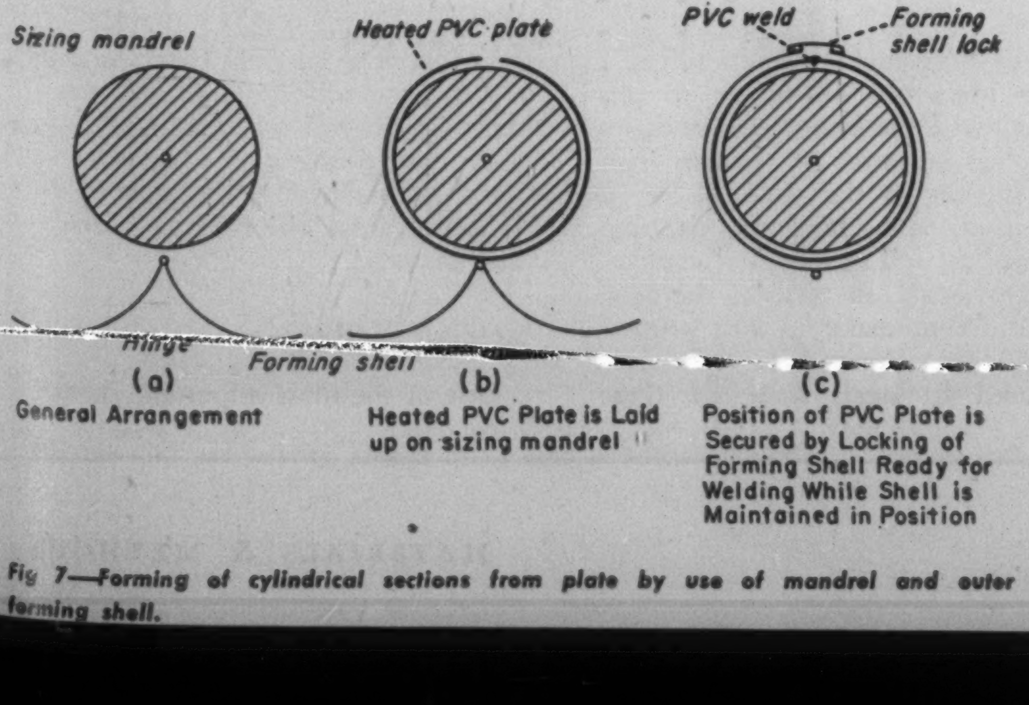


Fig 8 (right)—Principle of forming cylindrical sections from plate by use of collapsible mandrels.



General Arrangement

Heated PVC Plate is Laid up on sizing mandrel

Position of PVC Plate is Secured by Locking of Forming Shell Ready for Welding While Shell is Maintained in Position

Fig 7—Forming of cylindrical sections from plate by use of mandrel and outer forming shell.

The recent appearance on the market of seamless round sections of rigid polyvinyi chloride up to 16 in. in dia, focuses interest on the forming from sheet and plate of relatively large diameter sections which are required in the fabrication of exhaust ducts, tanks and other cylindrical equipment sections. The entire plate section to be formed must be heated to a temperature in range B on Fig 2 and then is formed by one of several possible procedures of which three are illustrated in Fig 6, 7, and 8. In the method shown in Fig 6 the heated plate is wrapped around a removable mandrel with the aid of a strong, smooth cloth which is kept under constant tension in order to assure optimum conformance to the mandrel contour. Fiber-board, wood or steel mandrels can be employed, with the latter preferred. Steel mandrels bring about the fastest cooling in polyvinyl chloride plate and therefore reduce to a minimum the "spring-back" tendency of heat-formed sections.

A modification of the above method consists of the use of two concentric cylinders serving as mandrel and forming shell respectively (Fig 7). While the forms used in the latter method serve simultaneously as jig in the welding of the longitudinal seams, considerably lower tooling costs make the "cloth wrapping" method (Fig 6) more attractive in many instances. A further modification of the method shown in Fig 6 is employed in the forming of large diameter sections, where full mandrels are impractical and only a circle segment is employed in conjunction with a tension cloth to produce contour conformance.

The use of collapsible—primarly wood—mandrels, such as illustrated in the method in Fig 8 is predominant in Europe. This method consists of completing all longitudinal welds in a "collapsed form", which is produced by warming and subsequent folding-over of the plate. After renewed warming, the welded body is then drawn over the collapsed mandrel, which is expanded to its maximum size by the use of wedges, and finally cooled as quickly as possible. Upon cooling, the formed cylinder is easily slipped from the mandrel by removal of the wedges. While this method permits the greatest degree of dimen-

Rigid polyvinyl chloride sheet can be readily shaped by drawing or pressing. Left, sheet is placed in press after being heated in preheating oven; right, pressed part being removed from press.

sional exactness and allows the use of various plate thicknesses, its drawbacks of double heating of the stock and the high cost of collapsible mandrels must be considered.

Deep Drawing and Vacuum Forming

Drawing and vacuum forming processes have been employed successfully with rigid thermoplastic sheet, including polyvinyl chloride copolymer sheeting, for some time. These applications, though, pertained primarily to decorative and consumer goods produced in large quantities, where the overall economy as well as versatility—primarily of the vacuum drawing process—have created broad fields of applications for thermoplastic sheeting.

In the industrial field it was primarily the deep drawing method using male and female molds, which found much use in Europe in the production of pipe fittings and similar items. The constant improvement in vacuum forming equipment has made possible the production of "semi-finished" products, such as dished tank heads or head sections. These developments provide the fabricator of rigid polyvinyl chloride an extremely economical and versatile tool.

In view of the heavy wall thickness (1/8 in. to 3/8 in.), which can be employed for various vacuum drawn "preforms", it is not possible to preheat these sheets in the standard form, employing infra-red heating blankets, but rather it is necessary to carry out this warming in an oven, and then place the heated sheet or plate into the mold to carry out the drawing.

Space limitations make it impossible to go into complete detail in this extremely important phase in the fabrication of rigid polyvinyl chloride but it must be pointed out that the heat formability of a good quality sheet or plate of this material offers the fabricator a great realm of possibilities to effect savings on fabrication work.

Joining Methods

While many plastics materials offer a high degree of chemical resistance, this property cannot be utilized unless means are available for their fabrication into complete units or structures. Many chemically resistant plastics are not easily joined to each other and to other materials, mainly because of their inherent chemical inertness, which makes chemical bonding impossible.

Rigid polyvinyl chloride offers a highly important advantage in this respect, since the joining to itself can be carried out with procedures basically known in the field of metal fabrication, i.e. bolting, riveting, welding, as well as chemical cementing. Obviously, in view of the basically different make-up and properties of rigid polyvinyl chloride when compared to steel, some of these methods, and welding in particular, had to be modified. However, welding, which will be discussed in greater detail below, has been one of the chief factors in the growth of rigid polyvinyl chloride as a structural material.

Welding Methods

One of the most important characteristics of rigid polyvinyl chloride is that it can be welded by several welding processes, which are carried out within Zone D of Fig 2. Through the use of pressure at this temperature, a lamination of fusion between parts of the material can be affected and it is therefore possible to fabricate large and intricate structures by joining individual sections of prefabricated forms. Depending upon the type of heating at the fusion zone, three welding procedures are listed as:

Hot gas welding.
Friction welding.
High frequency welding.

Without question, the most important and most versatile welding method for rigid polyvinyl chloride sections is the hot gas welding method, the principle of which is similar to that of the oxyacetylene welding of metals. The welding process requires a stream of heated inert gas (nitrogen, carbon dioxide, air, etc). The filler rod used in hot gas welding is usually identical in composition to the sections being joined. In the metallic welding process joining takes place in the molten puddle and the welding filler rod is consumed in a drop-like transition into this pool, the plastic welding process takes place only on the surface of the parent materials and the welding filler rod. The filler rod is laid down into the welding joint while the hot gas stream heats simultaneously the filler rod and the parent material. Fig 9 shows the theoretical aspect of the welding process while in Fig 10 and 11 a welding operator in action can be seen. Deposition of multi-layer welds for heavier sections employed in larger structures is easily accomplished by the hot gas welding process.

Welding temperature must be closely controlled since insufficient heat leads to poor bonding. Overheating results in decomposition and burning which also occurs when the proper welding temperature is maintained for an excessive period on a localized area. As Fig 9 shows, a constant fan like motion is carried out with the welding torch nozzle between the parent material and the filler rod. In view of the poor heat conductivity of the material and the relatively high temperature of the inert welding gas (500 to 550 F), a rapid local decomposition would occur if this motion were not maintained. Overheating is easily recognized by the formation of small blisters and darkening at the fusion zone. Overheated sections must be removed before any further welding is carried out at this point. Overheating is generally a sign of insufficient experience or carelessness on the part of the welder and is generally avoided with experienced personnel.

The handling of the welding filler rod has great effect on the weld quality. Necessary hand pressure on the welding filler rod should be exerted at a 90 deg angle to the direction of welding (Fig 10). Handling

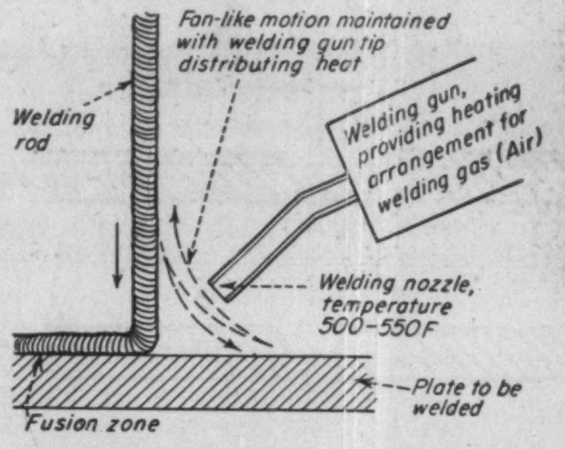

Fan-like motion maintained with welding gun tip distributing heat
Welding rod
Welding gun, providing heating arrangement for welding gas (Air)
Welding nozzle, temperature 500-550F
Plate to be welded
Fusion zone

Fig 9—Principle of hot-gas welding method for rigid polyvinyl chloride, employing hot air as heating medium.

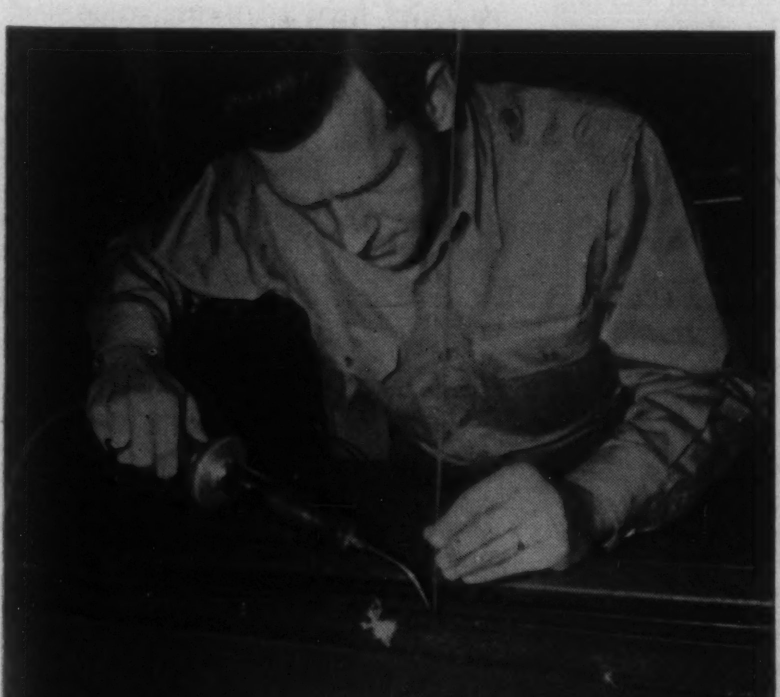


Fig 10—Hot gas welding process being used in horizontal plane.

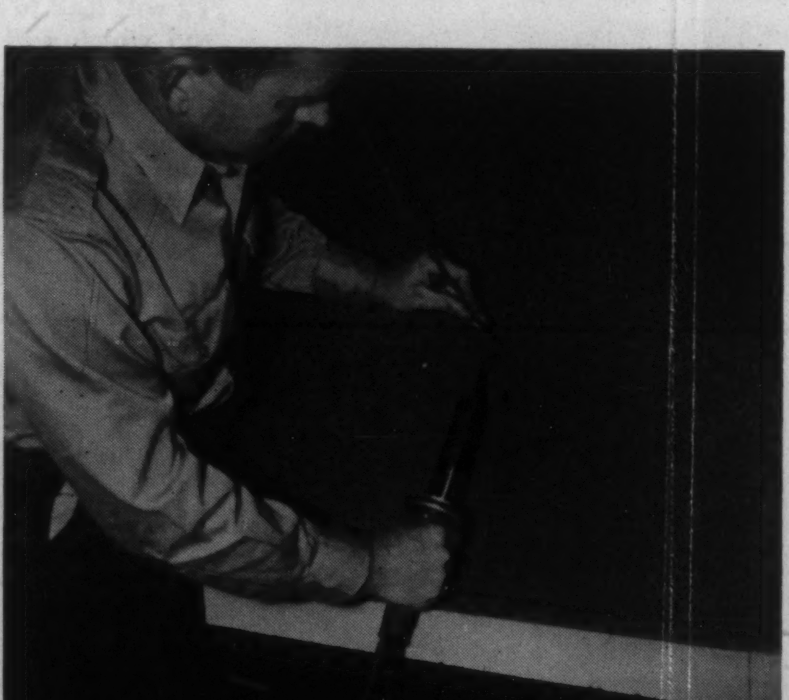


Fig 11—Hot gas welding process being used in vertical plane.

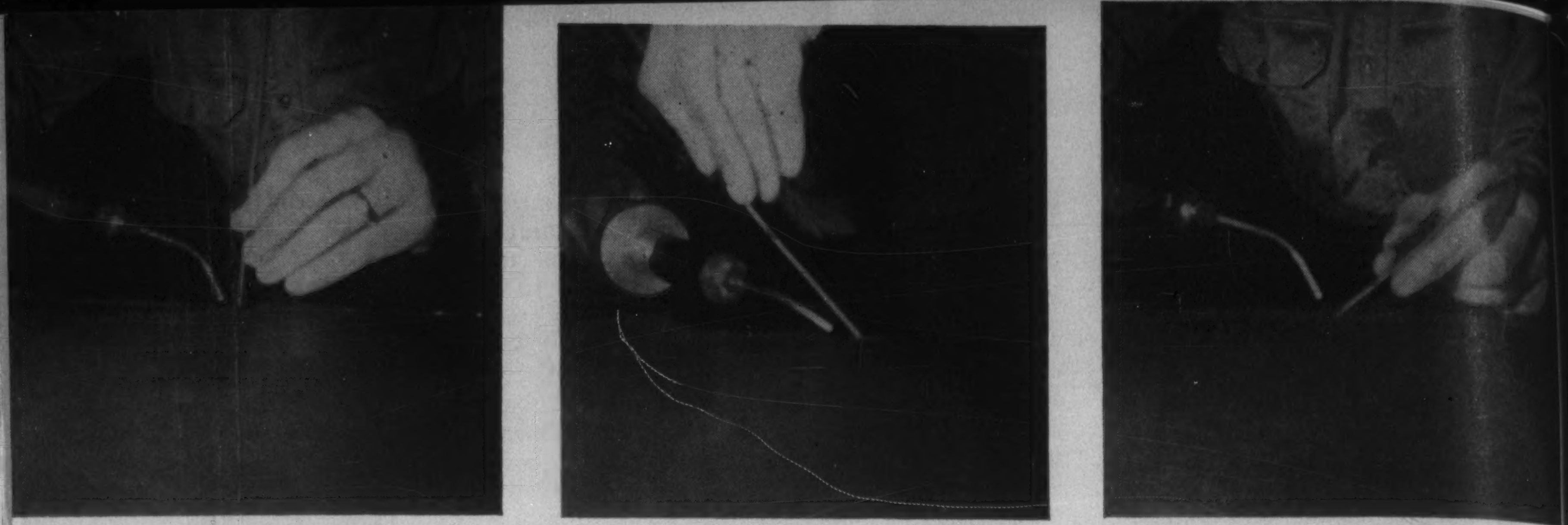


Fig 12—Correct (left) and incorrect (center and right) guiding of welding rod.

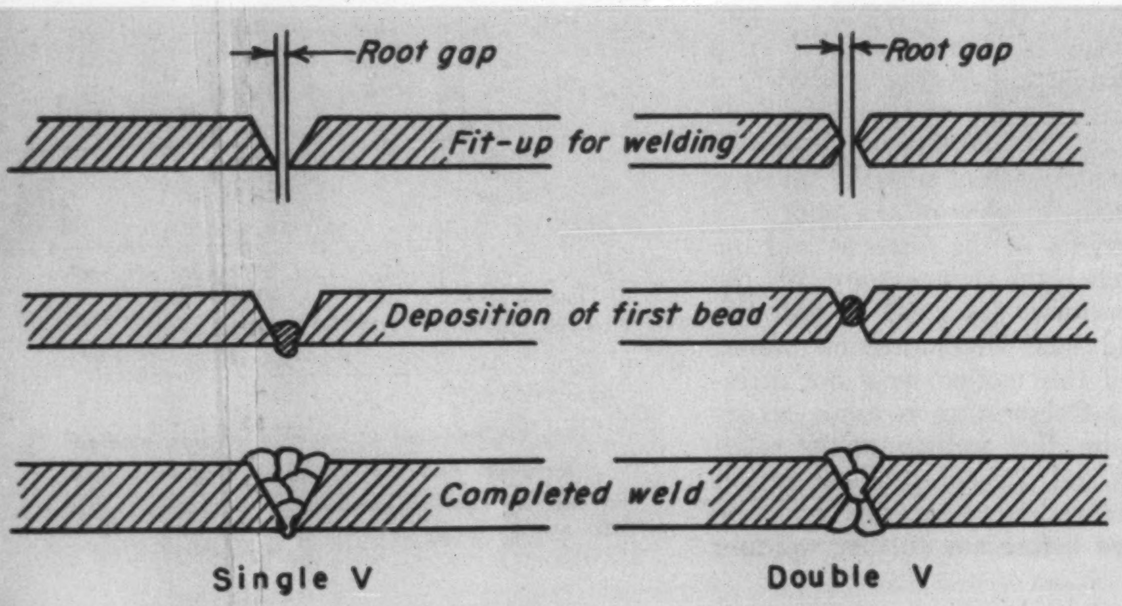


Fig 13—Fit-up of butt-joints for hot-gas welding.

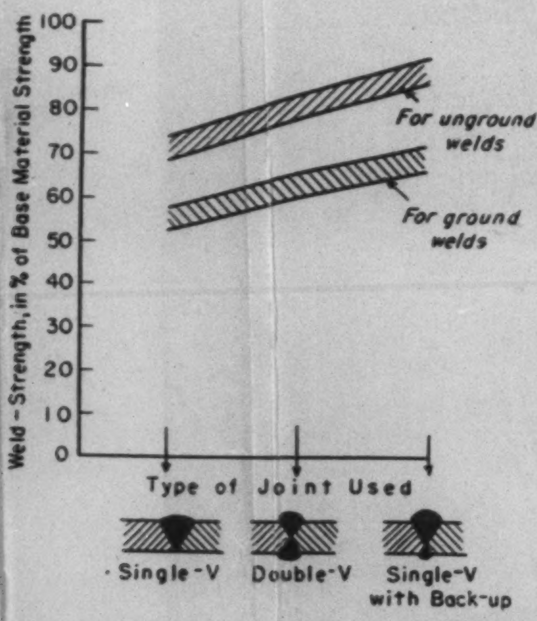


Fig 14—Comparison of welding strength of butt-joints in rigid PVC.

of the welding rod as shown in Fig 12 will lead to tension in the welding rod which will not be obvious until a second bead is deposited over the first one and then will result in the release of the stresses and bring about cross checking and cracks of the weld.

As in the welding of steel, thorough root penetration in welded joints is equally important in the welding of rigid polyvinyl chloride, which has to be provided through procedures which are illustrated in Fig 13. This is assured by allowing a small gap at the root of the weld, regardless of whether a V or double V joint is used. This gap permits the initial bead to penetrate into the root of the weld and root soundness is assured thereby. The most advantageous angle in the preparation of the joints is between 60 and 70 deg. In the preparation of corner joints the bevelling angle is reduced to 45 deg, since otherwise the welded zone would be to broad.

Fig 14 shows the comparative weld strengths of the three basic forms of welded joints obtained in tests of average welders. Present experience on welder evaluation has shown that the average welder will pass welding tests with about 80 to 85% weld strengths, and that welders who can not achieve 75% weld strengths on regularly scheduled spot tests, should not be permitted to carry on production work.

In discussing weld properties it should point out the difficulty involved in deforming the welded joint. Notch sensitivity of the welded joint is lower than that of the parent material. Under extremely high loads, the notch sensitivity of the welded joints tends to spread into the base material so that sometimes fractures, which actually originate in the welded joint will produce irregular cracks in the base material.

Friction Welding

In this process welding heat is generated through friction, whereby the sections to be welded are rotated against each other under pressure. When the welding temperature is reached, the relative motion of the two parts is stopped and the parts are pressed together.

High Frequency Welding

High frequency welding is the most modern welding procedure, but its application to rigid polyvinyl chloride is restricted to rather thin sections and is finding considerably more use in the field of plasticized polyvinyl chloride.

Cementing

Rigid polyvinyl chloride can be cemented easily, but this method of joining is of importance primarily in the lining of steel, concrete, or wood tanks and vessels with thin sheeting and foils of the materials. Cementing is frequently employed in connection with hot gas welding of pipe connections. Both methods of joining, i.e. welding and cementing, complement each other in such applications to achieve completely pressure-tight fits.

Mechanical Joining

Joining by the use of screws, bolts, or rivets is identical to the procedures followed with other structural materials, except that the high notch sensitivity must be taken into account when screws and bolts of the same material are employed. Therefore rounded threads should be applied wherever possible.

Design Suggestions

Rigid polyvinyl chloride is rapidly finding recognition as a high grade structural material in the field of chemical equipment construction. Beside the chemical and allied industries, where chemical resistance is of major interest, rigid polyvinyl chloride has been able to establish itself also in the optical and electrical industries, in the manufacturing of measuring devices, ventilating and air-conditioning systems, the aircraft and marine construction field as well as the fruit and beverage industries.

The engineer or fabricator must have a clear picture though, that only where it is possible to take advantage of its many good properties, will it pay to employ rigid polyvinyl chloride.

In view of some of the particular properties described previously certain basic design rules must be considered in order to avoid failures. Particular attention should be called to the high notch sensitivity of rigid polyvinyl chloride and since this property cannot be improved appreciably by compounding, without impairing other desirable properties, high notch sensitivity must be taken into account in all fabrications.

Therefore in Fig 15 are shown some of the rights and wrongs of the particular aspect of high notch sensitivity and its application to design which can be summarized as follows:

Avoid sharp cross-sectional transitions;

Where sharp transitions are unavoidable, use rounded transitions in order to minimize the notch effect;

Where threaded joints are necessary, employ a rounded cross section wherever possible;

Overstressing of equipment sections by forcing them into position should be avoided;

Post-forming of poorly fitted sections through the application of heat in order to achieve a perfect fit should be avoided since thermal stresses will be retained and could be the cause of ultimate failure.

Particular attention must be given to the types of welded joints employed in various applications because welding strengths vary greatly. An experienced welder will produce welded joints which average 80 to 90% of the strength of the base material so that for all practical purposes a welding factor of 70% can be relied upon. The welding factor is always related to cross section of the base material and not to the actual cross section of the welded joint which is usually larger. Therefore any weld which is sanded or ground down to the identical cross section of the base material, must be reduced by 10% to 20% in its welding value. Under certain conditions, particularly when the welded joint is subjected to a continuous flexural load, sanding of the weld to the actual cross section of the base will be advantageous.

While the production of a butt joint such as shown in Fig 13 does not present too many problems, several types of welds are possible for corner and fillet joints as are shown in Fig 16.

For economy and strength, structural corners should be produced by bending wherever possible, and welds should be located in positions where butt joints are possible wherever the design allows. Jigging

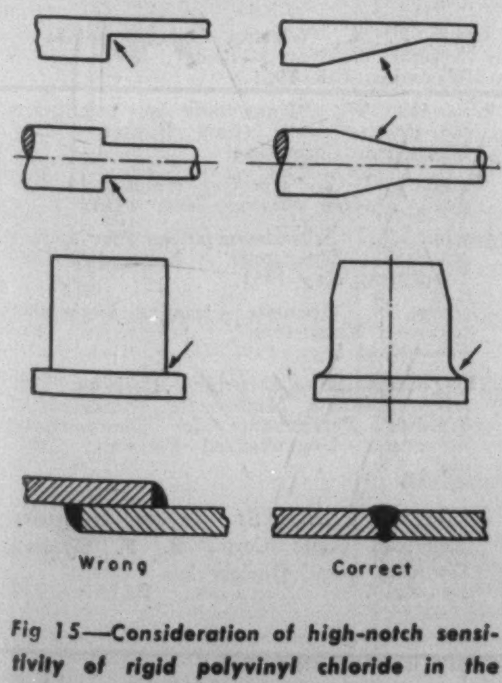


Fig 15—Consideration of high-notch sensitivity of rigid polyvinyl chloride in the design of fabricated units.

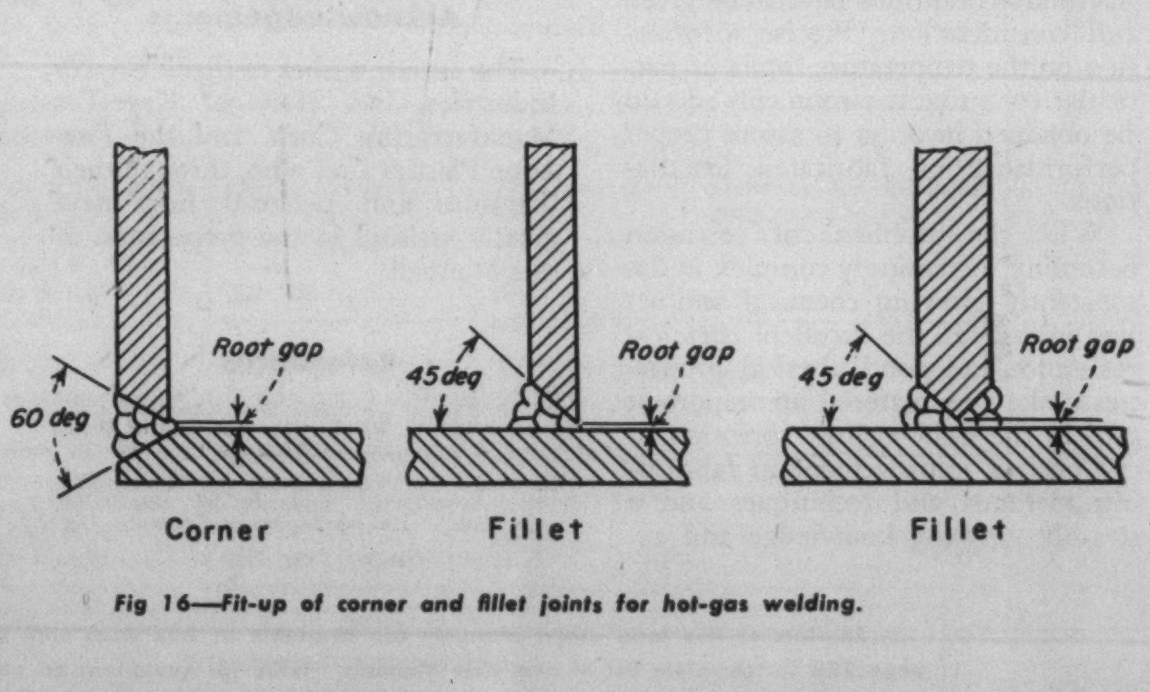


Fig 16—Fit-up of corner and fillet joints for hot-gas welding.

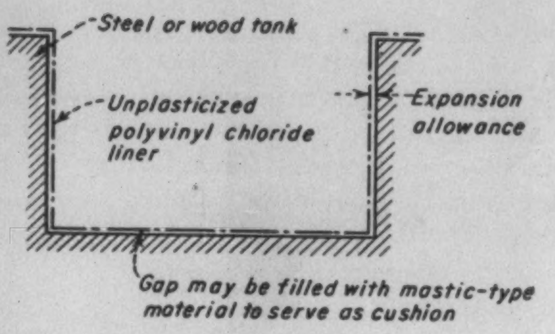
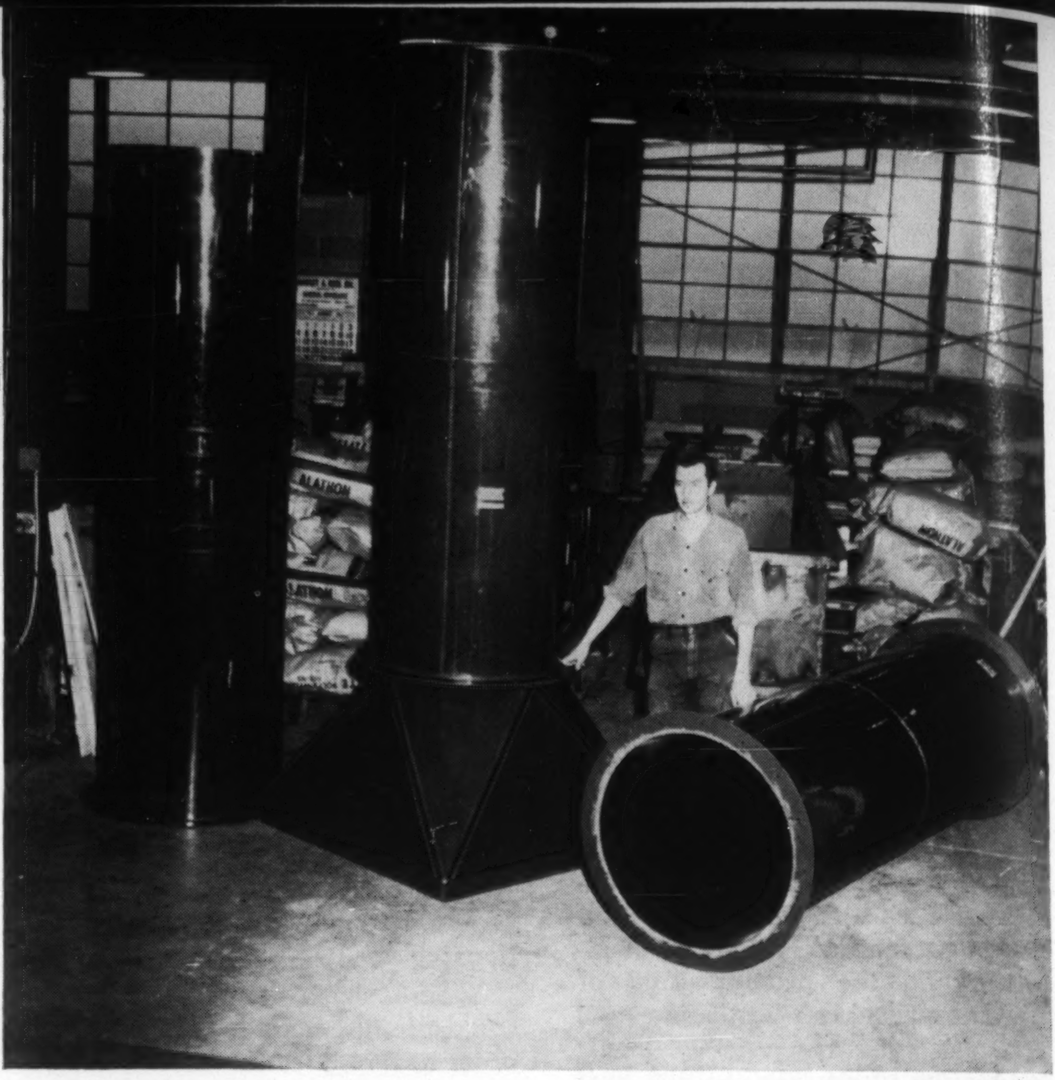

Steel or wood tank
Unplasticized polyvinyl chloride liner
Expansion allowance
Gap may be filled with mastic-type material to serve as cushion

Fig 17—General arrangement of tank liners made from rigid polyvinyl chloride sheet.



A 30-ft high exhaust stack (30-in. dia) to handle fumes from 18% nitric acid and 3% hydrofluoric acid mixture.

and weld preparation will be considerably simpler for butt joints than for corner and fillet joints.

In view of the obvious tensile and flexural strengths limitations of rigid polyvinyl chloride, the fabrication of large self-supporting structures which are under continuous internal load, such as various types of tanks, presents the fabricator with certain problems. Some large structures seemingly require extremely heavy cross sections of plate which might make such fabricated shapes economically unsound. It is possible to fabricate tanks of this type of thinner plate thickness and reinforce them with a steel or wood "basket" and similar supporting arrangements. The use of rigid polyvinyl chloride for the purpose of lining steel vessels and tanks presents certain difficulties in view of the great difference in the coefficient of expansion of steel and these plastics which would become a source of trouble if the particular piece of equipment is subjected to variations in operating temperatures. Therefore when rigid polyvinyl chloride is used as a loose liner, provision should be made for the above mentioned difference in coefficient of expansion by allowing sufficient play between the tank and the liner as is shown in Fig 17. Past experience has shown that it is absolutely necessary, that any liner of this type must be built in the tank, since it is impossible to produce such "loose" liners for insertion into a fabricated steel tank without encountering considerable fitting difficulties which will lead to stressing of various sections of the liners.

Conclusion

The foregoing should help both prospective fabricators and ultimate users of equipment made from rigid polyvinyl chloride realize that in addition to the chemical resistance, a number of physical properties and operating conditions have to be given full consideration. Precise information on the temperature limits of particular corrosive environments should be obtained in order to assure proper performance of fabricated installations.

With the problems of corrosion becoming increasingly complex in the constantly growing chemical and allied industries, the excellent chemical resistance and good physical properties make this material an important tool in the fight against corrosion.

Constant improvement in fabricating methods and techniques and a steadily growing knowledge and experience in proper design assure rigid polyvinyl chloride a bright future as structural material if its advantages and limitations are fully understood.

Acknowledgements

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References

U. S. Patent 2,220,545 Dow Chemical Company (R. D. Reinhardt): "Method of Welding Thermoplastic Materials."

Dammer, O., "Verarbeitung von Kunststoffen im Apparatebau und in der chemischen Technik", *Chemie-Ingenieur-Technik,* Oct. 1952.

Haim, G. & Zade, H. P., "Welding of Plastics." (Crosby, Lockwood & Son, Ltd. London, E.C.4.)

Henning, A., "Das Schweissen thermoplastischer Kunststoffe", *Kunststoffe,* April and June 1942.

Huscher, J. L., "Unplasticized Polyvinyl Chloride", *Chemical Engineering,* Nov. 1952.

Jaroff, L. M., "Plastics Can Be Joined by Several Welding Methods", MATERIALS & METHODS, Feb. 1951.

Krannich, W., "Kunststoffe im technischen Korrosionsschutz". (Carl Hanser Verlag, Muenchen, Germany.)

Neumann, J. A. "Hot Gas Welding of Plastics", *Modern Plastics,* Nov. 1950.

Pischke, H. "Schweissverfahren fuer thermoplastische Kunststoffe", *Schweissen und Schneiden,* May 1951.

Pischke, H. "Spanlose Formung thermoplastischer Kunststoffe", *Schweissen und Schneiden,* Sept. 1951.

SPI-Thermoplastitc Structures Division, "Tentative Standard Method for Evaluation of Welding Performance for Thermoplastic Structures—Unplasticized Polyvinyl Chloride".

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Conditions for Electrolytic Polishing of Metals and Alloys

Metal	Electrolyte Composition[1] cu cm	Current Density amp/sq dm	Voltage	Temp F	Time Min	Remarks	References
PURE METALS Aluminum	P, 165; AA, 785; W, 50	3–5	50–100	<120	10–15	4 to 5 g/l aluminum for best electrolyte, excellent polish	14, 32
	P,110; AA, 400	4		<120		excellent electron micrographs	19
	P, 170; AA, 785; W, 45	5–9		<120	15–20		20
	P, 45; E, 800; W, 155	200–400	100–200	< 95	8–12[2]		7, 55
	P,70; E, 800; W, 130	60–100	25–35		15–30[2]		9
	O-P, 1000; agar-agar, 10 g; sodium hydroxide, 10 g	⟵ Commercial Electrolyte ⟶					49
	Nitric acid, 200; methanol, 400; sodium hydroxide, 50 g; casein, 0.4 g; W, 1000	⟵ Commercial Electrolyte ⟶					49
Beryllium	O-P (98%), 1000; S, 50	100					37
	O-P, 100; S, 30; glycerine, 30; ethanol, 30	200–400				excellent polish for polarized light	37
Bismuth	O-P, 200; S, 400; W, 400	100				satisfactory for polarized light	37
	Saturated potassium iodide acidified with hydrochloric acid					some pitting	37
Cadmium	O-P, 400; W, 200; glycerine, 400	40				excellent for polarized light	37
	Potassium cyanide, 10 g; cadmium hydroxide, 17.5; W, 1000	⟵ Commercial Electrolyte ⟶					55
	Sodium hydroxide, 24%	40		70–85		good for electron micrographs	19
Chromium	P, 50; GA, 1000; W, 5–15	15–20	24–26	70–85		excellent surface	23
	Ethanol, 144; aluminum chloride, 10 g; W, 32; N-butanol, 16; zinc chloride, 45 g		20–24		5–15		10
Cobalt	O-P, 490; W, 510		1.2			etch pits	20, 32
	Ethanol, 144; aluminum chloride, 10 g; W, 32; N-butanol, 16; zinc chloride, 45 g						10
Copper	O-P or P-p, 370; W, 630	8–10	1.6–2.0	70	10–15		32, 40
	O-P, 530; W, 470	0.65–0.75	2	72	>5		31, 40
	O-P, 85%	6	25	68	5		20, 32
	O-P, 500; W, 500		2.5	60–70	1–2		14
	O-P, 690; W, 310		1.8–1.9	72	25–30	good method	22
	O-P, 670; S, 100; W, 270	10	2–2.2	72	15	excellent polish	41
	O-arsenic acid, 840 g; chromium trioxide, 100 g; W, 60 g	⟵ Commercial Electrolyte ⟶					55
Gold	Potassium cyanide, 30 g; potassium ferrocyanide, 10 g; W, 1000	⟵ Commercial Electrolyte ⟶					29
	Gold chloride, 0.5%; potassium cyanide, 10%	10–15	0.8–1.2	72	1	preferred for 14 carat gold	13
Iron	P, 185; AA, 765; W, 50	4–8	50	85	4–10		9, 47
	P, 85; E, 800; W, 115	200–500		68	10–15[2]	good	8, 32
	O-P, 1000; oxalic acid, 10 g; gelatin, 10 g	⟵ Commercial Electrolyte ⟶					49
	O-P, 530; W, 470	0.6	0.5–2.0	60–70	8–10	good	32
	O-P, 500; ethylene glycol, 500	7.5–15.5		120–175	15	good	32
	S, 400; glycerine, 400; W, 300	⟵ Commercial Electrolyte ⟶					55
Lead	P, 235; AA, 675; W, 90	20–40		68			32
	P, 352; AA, 628; W, 20	9–11		68			32
	P, 70; E, 800; W, 130	200–300	45–60	68	15–30[2]		9
	P, 300-340; GA, 660-700	⟵ Commercial Electrolyte ⟶					55

(Continued on page 139)

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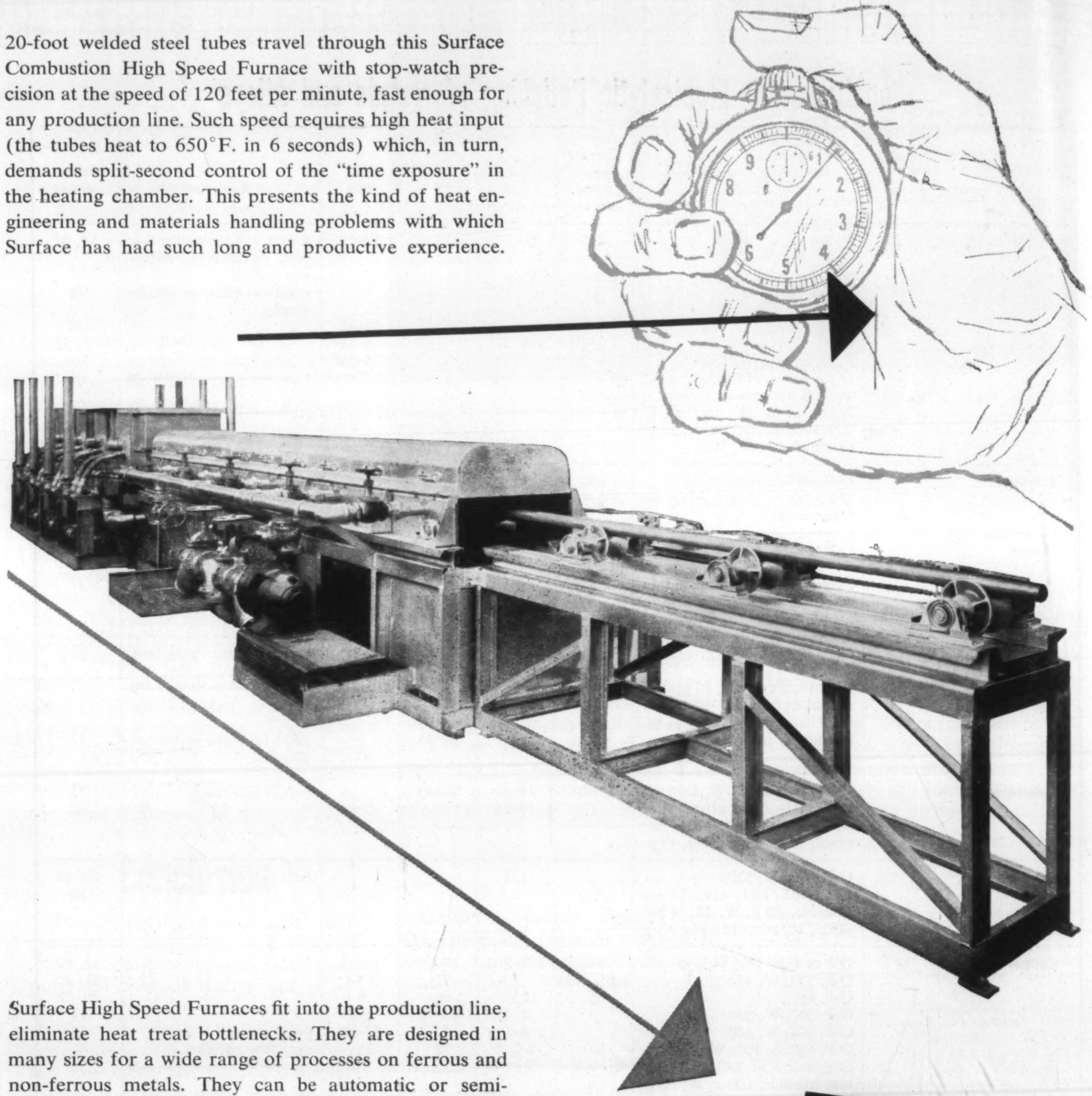
stress relieving at 120 feet/minute

20-foot welded steel tubes travel through this Surface Combustion High Speed Furnace with stop-watch precision at the speed of 120 feet per minute, fast enough for any production line. Such speed requires high heat input (the tubes heat to 650°F. in 6 seconds) which, in turn, demands split-second control of the "time exposure" in the heating chamber. This presents the kind of heat engineering and materials handling problems with which Surface has had such long and productive experience.



Surface High Speed Furnaces fit into the production line, eliminate heat treat bottlenecks. They are designed in many sizes for a wide range of processes on ferrous and non-ferrous metals. They can be automatic or semi-automatic, gas or oil fired. Write for Literature Group H53-5 and see how these "hot-rod" furnaces can give you savings in heating time, equipment cost, fuel, maintenance, floor space, metal, and labor.

Surface
HEAT TREATING EQUIPMENT

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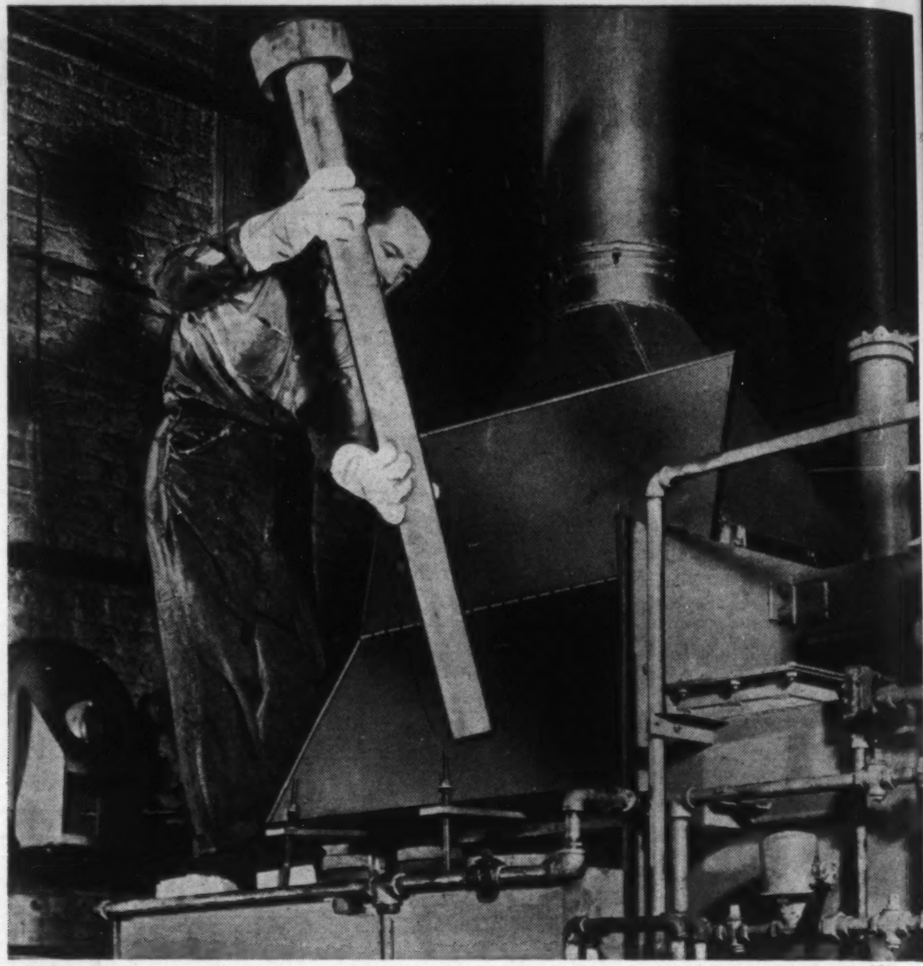
Conditions for Electrolytic Polishing of Metals and Alloys—Continued

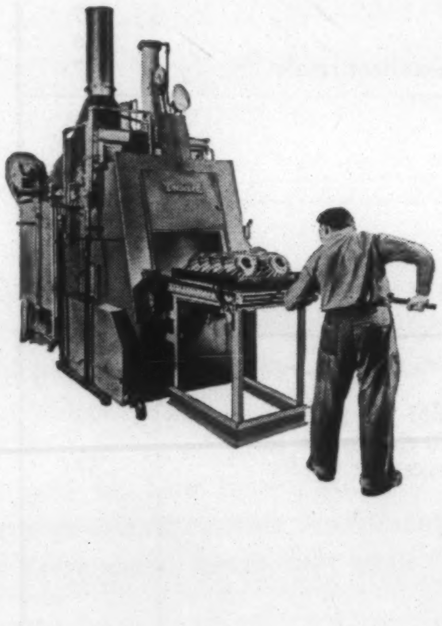
Metal	Electrolyte Composition[1] cu cm	Current Density amp/sq dm	Voltage	Temp F	Time Min	Remarks	References
Magnesium	P, 200; ethylene glycol, 800	1	1–5	70–85		good polish	2
	O-P, 375; ethanol, 625	0.5–1	1.5		3–5		2
	Hydrochloric acid, 100; ethylene glycol, 900	1	10–15	<50			2
Molybdenum	S, 35; W, 140		12	120		sintered molybdenum only	4
	Hydrochloric acid, 50; S, 20; methanol, 150		12	120		sintered or cast molybdenum	4
Nickel	P, 210; AA, 790	18	22	68		excellent surface	25, 54
	S, 400; glycerine, 400; W, 300	←Commercial Electrolyte→					55
	S, 400 g; hydrofluoric acid, 100 g; W, 500 g	←Commercial Electrolyte→					55
	S, 390; W, 290	39	8–10	95	4–6		47, 52
Silver	Sodium cyanide, 100 g; Potassium ferrocyanide, 100 g; W, 1000	←Commercial Electrolyte→					49
	Silver cyanide, 35 g; potassium cyanide, 30 g; potassium carbonate, 38 g; W, 1000	1–1.2	1–1.8	72	10 & 10	excellent, special polish technique	48
Tantalum	S, 90; hydrofluoric, 10	10		95–110	9		53
Tin	P, 194; AA, 806	9–15	25–45	70–85	8–10	excellent polish	20, 32
	P, 280; AA, 720	3–6	15	70–85	100–200[2]	excellent polish	21, 47
Titanium	P, 10; AA, 200	100		<40	4		30
	P, 25; E, 750; W, 70	100			10–20[2]		42
	Hydrochloric acid, 250; ethanol, 750	100			10–20[2]		42
Tungsten	Sodium hydroxide, 100; W, 900	3–6		68	20–30		32, 55
Uranium	P, 900; W, 100	100					37
	P, 50–100; GA, 1000	5–10	10–20	70–85	<5		26
	O-P, 200; S, 400; W, 400	50–75			5–10	excellent results	37
Zinc	P, 85; E, 800; W, 115	80	50	<95	10[2]		5, 8
	Chromic acid, 200 g; W, 1000	200–250					43
	Potassium hydroxide, 25%	16	2–5	68	20–30		20, 47
Zirconium	P, 25; E, 450; W, 70	100		70–85	10–20		42
	P, 80; GA, 910; W, 10	1–15	12–18	70–85	45[2]		45
	Hydrochloric acid, 250; ethanol, 750	100		70–85	10–20		42
NON-FERROUS ALLOYS							
Aluminum-base:							
General	P, 170; AA, 785; W, 45	5–9		<120	15–20	add 3 to 5 g/l aluminum to electrolyte	20
Dural, Y-alloy Al-Mn, Al-Fe, Al-Mn-Zn, Al-Mg-Zn-Mn-Cr	P, 165; AA, 785; W, 50	20–70	210	70–85	0.5–3	excellent results	57
Al-Cu-Ti, Y-alloy, Alpax Al-Cu, Al-Mn	P, 45; E, 800; W, 155	200–400	150–220	70–85	10–30[2]		7
Al-Ni, Al-Mg, Al-Zn, Al-Si	P, 70; E, 800; W, 130	10–20	25–35	20–30	15–30[2]		9
Al-Zn-Mg	O-P, 1000; CrO_3, 300 g	7–50	3–12	120–195	20–60[2]	excellent results	23
Copper-base:							
Alpha-brass	O-P, 300; W, 700	13–15	1.9	60–75	10–15		20, 40
Alpha + Beta brass	O-P, 370; W, 630	9–11	1.9	60–75	10–15		20, 40
Bronze (3—6Sn 0.4P)	O-P, 450; S, 150; W, 400	10	2–2.2	60–75	15		41
Bronze (Al, Pb)	O-P, 690; W, 310	1–2		60–75			20, 40
Bronze (Si)	Nitric acid, 200; Methanol, 400		40–50	70–120	5–10[2]		40
Nickel-silver	O-P, 85%		2–2.2	60–75	15		12

(Continued on page 141)



Inconel radiant tubes in new Lindberg multi-purpose furnace come out on top!

Time for a Change? It's no job at all to slip one of these thin-wall Inconel vertical tubes into the new Lindberg Carbonitriding Furnace. The tube collar, which forms a heat seal, is shaped from Inconel sheet and welded to the tube. These lightweight tubes transfer heat efficiently, yet give long service life because of Inconel's resistance to oxidation and many corrosive atmospheres at high temperatures.



You would hardly believe that replacing a radiant tube could be this simple – *but it is!*

In the carbonitriding furnace recently developed by the *Lindberg Engineering Company*, of Chicago, all you do is lift out the old tube and hang a new one in its place.

Inconel® tubes like the one shown above weigh only 29 pounds.

Yet they are sturdy and long-lasting. They resist oxidation and many corrosive furnace atmospheres at high temperatures. They must, for tubes really get a workout in this furnace! Lindberg designed it to handle not only carbonitriding, but hardening, carburizing, annealing and carbon restoration as well. Different furnace atmospheres are supplied by an adjustable generator.

Inconel takes all of these varying conditions in stride. It resists cracked ammonia and carbon monoxide atmospheres, and provides excellent strength throughout the entire carbonitriding temperature range. Its good strength persists at temperatures up to 2,200°F. Also, it is readily workable and can be welded by ordinary shop methods.

You can see, then, why Lindberg has standardized on Inconel tubes for their new furnace.

To learn how Inconel can serve you in troublesome high-temperature applications, write for a copy of the booklet, *Keep Operating Costs Down... When Temperatures Go Up.* It's yours on request.

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MATERIALS & METHODS
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Conditions for Electrolytic Polishing of Metals and Alloys—Continued

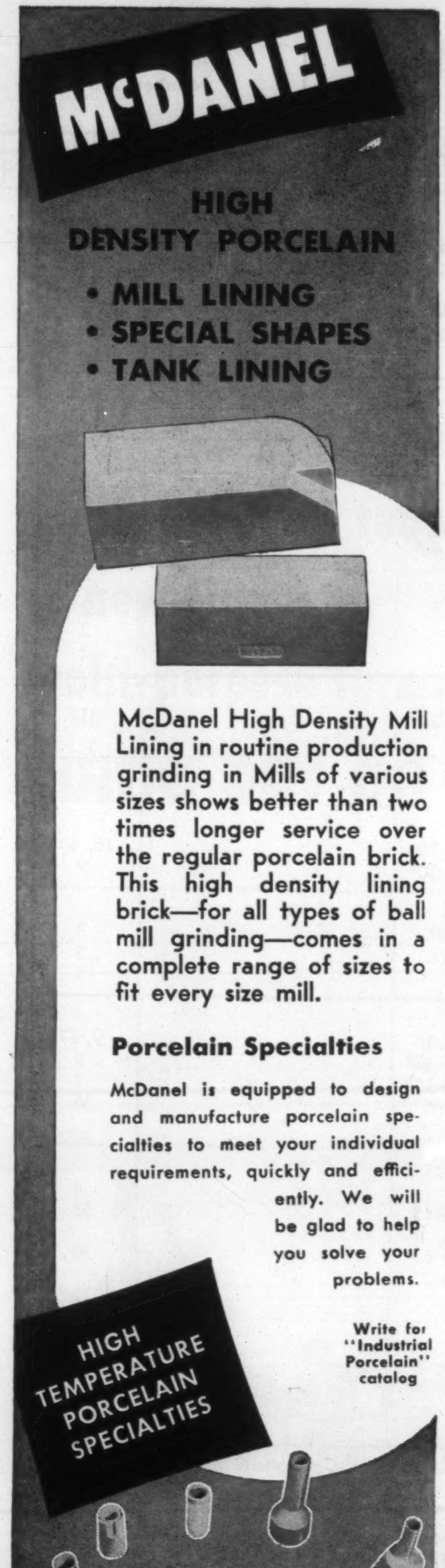
Metal	Electrolyte Composition[1] cu cm	Current Density amp/sq dm	Voltage	Temp F	Time Min	Remarks	References
Gold-base:							
14 K gold	Potassium cyanide, 10%	1–2	1.2–1.6	70–85	1		13
Lead-base:							
Pb-Sn (100—0% Pb)	Fluoboric acid, 40% + Sulfuric acid, 2%	400–700	15–20	70–115	3–5[2]		38
Pb-Sn-Cd	P, 85; E, 800; W, 115	300–400	25–30	95	10[2]		5
Pb-Sn-Sb	P, 85; E, 800; W, 115	250		95	45–60[2]		5
Magnesium-base:							
Mg alloys	O-P, 375; E, 625	0.5–1.0	1.5		3–5		2
Mg (6Al, 12Zn)	P, 270; AA, 730	0.5	20–30	<85			2
Mg (2Mn)	P, 270; AA, 730	10					2
Nickel-base:							
Monel	Nitric acid, 200; methanol, 400	12.5–15	2.4–2.6	70–85	7–10		31
Nichrome	Nitric acid, 200; methanol, 400		40–50	70–85	5–10[2]		40
Tin-base:							
Sn-Sb	P, 194; AA, 806	10	25–40	<85	8–10		20, 40
Sn alloys	P, 70; E, 800; W, 130	200–300	45–60	70–85	15–30[2]		9
Zinc-base:							
Zinc alloys	P, 85; E, 800; W, 115	120–190	20–45	<95	10[2]		8
Zn (4Al, 1Cu)	P, 85; E, 800; W, 115	100–200	35–60	<95	10[2]		5
Zn (7Al, 4Cu)	P, 85; E, 800; W, 115	60	100	<95			5
FERROUS ALLOYS							
Carbon or Low Alloy	P, 185; AA, 765; W, 50	4–7	50	<85	4–10		9, 17
Hypo	P, 70; E, 800; W, 130	250–400	35–70	<95	15–30[2]		9
Hyper	P, 200; E, 800; W, 155	400–500	110	<95	10–15[2]		7
Martensitic	Glacial acetic acid, 135; CrO_3, 25; W, 7	90–250	20	65	4–6		36
Stainless Steels:							
18:8	P, 85; E, 800; W, 115	50–600		70–85			8
18:8	O-P, 420; glycerine, 470; W, 150	15–20		212	8–15		32
18:8	Glacial acetic, 133; CrO_3, 25 g; W, 7	90–250	20	65	4–6		36
High Chromium	P, 30; GA 1000; W, 10	15–20	24–26	70–85			23
Cast Iron:							
White	P, 85; E, 800; W, 115	50–600	110	70–85	15–20[2]		8
Nodular	P, 70; E, 800; W, 130	60–100	10–15	70–85	15–30[2]		9
Gray	P, 200; E, 700; glycerine, 100; oxalic acid, 3% by weight	30–40	1.5	70–85			44

NOTES: [1] *P—perchloric acid; AA—acetic anhydride; W—distilled water; E—ethanol; GA—glacial acetic acid; O-P—ortho phosphoric acid; P-p—pyrophosphoric acid; S—concentrated sulfuric acid.*
[2] *Seconds.*

Compiled by S. H. Bush, on Navy Contract N6-onr-232, University of Michigan

REFERENCES

1. Audubert, M., Bonnemay, M. Lewartowicz, E., *J. des Recherches du Centre National de la Recherche Scientifique No 12:* 139—47, 1950
2. Black, G., *Metal Finishing 45:* 86—7, 84—6, June, July 1947
4. Coons, W. C.—*Trans. ASM 41:* 1415—24, 1949
5. Decker de, H. C. J., Krijff, A. P., Pluut, J. M., *3rd Int. Conf. on Electrodeposition,* London. 25—32, September 17—20, 1947
7. De Sy, A. and Haemers, H., *Rev. de Metallurgie 38:* 122—8, 1941
8. De Sy, A. and Haemers, H., *Metal Progress. 53:* 368—71, 1948
9. De Sy, A. and Haemers, H., *Metalen. 4:* No.7: 129—37, 1950
10. Evans, U. R., and Whitwham, D., *J. Electrodepositors Tech. Soc. 22:* 24—8, 1947
11. Faust, C. L., *J. Electrochemical Soc. 95:* 62C—72C., March 1949
12. Giroudot, M., *Rev. de Metallurgie 46:* 383—6, 1949
13. Gleekman, L. W., Evans, G. E. and Grove, C. S., Jr., *Metal Progress 60:* 92—3, 1952
14. Guy, A., *Metal Progress 46:* 105—6, 1944
16. Heyes, J., *Metalloberfläche* Ser. B *5:* B179—81, December 1951
17. Holleman, J. W. and Schultze, W. A., *Metalen 6:* 306—11 Aug. 31, 1951
19. Huber, K., *Chimia 4:* 54—62, Mar. 15, 1950
20. Jacquet, P. A., *La Technique Moderne 31:* 561—9, 1939 No. 16
21. Jacquet, P. A., *Metaux et Corrosion 14:* 61—4, 1939
22. Jacquet, P. A., *Rev. de Metallurgie 42:* 133—48, 1945
23. Jacquet, P. A., *Rev. de Metallurgie, 46:* 214—27, 1949
24. Jacquet, P. A., *Rev. de Metallurgie 48:* 1—16, 1951
25. Jacquet, P. A., *Metal Progress 59:* 65, 1951
26. Jacquet, P. A. and Caillat, R., *Comptes Rendus 228:* 1224—6, 1949
28. Knuth-Winterfeldt, E., *Metal Progress 60:* 80, 1952
29. Krause, H., *Electroplating and Metal Finishing 3:* 570—1, Nov. 1950
30. Leighly, H. P., *Metal Progress 49:* 79, 1951
31. Lippert, T. W., *Iron Age 146:* 23—30, Dec. 26, 1940
32. Longard, K., *Archiv fur Metallkunde 3:* 381—6, 1949
36. Morris, C. E., *Metal Progress 56:* 696—9, 710, 12, 14, 1949
37. Mott, B. W. and Haines, H. R., *J. Institute of Metals 80* Part 12: 629—36, 1952
38. Moulen, A. W., *J. Electrochemical Soc. 99:* 133C—66C, 1952
40. Pellissier, G. E., Jr., Markus, H., and Mehl, R. F., *Metal Progress 37:* 55—8, Jan. 1940
41. Perryman, E. C. W., *Metallurgia 46:* 55—7, July 1952
42. Roberson, A. H., *Metal Progress 56:* 667—9, Nov. 1949
43. Rodda, J. L., *Mining and Metallurgy 24:* 323, 1943
44. Roos, A., *Rev. de Metallurgie, 49 No 5:* 385—90, 1952
45. Roth, H. P., *Metal Progress 58:* 709—11, Nov. 1950
47. Schaefer, C., *Metal Industry 38:* 22—6, 1940
48. Shuttleworth, R., King, R., and Chalmers, B., *Metal Treatment 14:* 161—3, Autumn, 1947
49. Tajima, S., *Metalloberflache Sec. B4:* B54—B58, B73—B75, 1952
52. Wensch, G. W., *Metal Progress 58:* 735—6, Nov. 1950
53. Wensch, G. W., Bruckart, K. and Conolly, M., *Metal Progress 61:* 81, March 1952
54. Wyart, J. and Epelboin, I., *Rev. de Metallurgie 47:* 511—4, July 1950
55. Young, C. B. F., Hesse, K. R., *Metal Finishing 45:* 63—7, 64—7, Feb., Mar., 1947
56. Zmeskal, O., *Metal Progress 47:* 729—36, April 1945
57. Mott, B. W., and Perryman, E. C. W., Protection and Electrodeposition of Metals. Report No. 8 pp 120—6—*v*3 Selected Government Research Reports H.M. Stationery Office, 1951, 350 pp.



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Thousands of tons of killed basic Bessemer steel have been used successfully in Germany for severe cold forming applications.

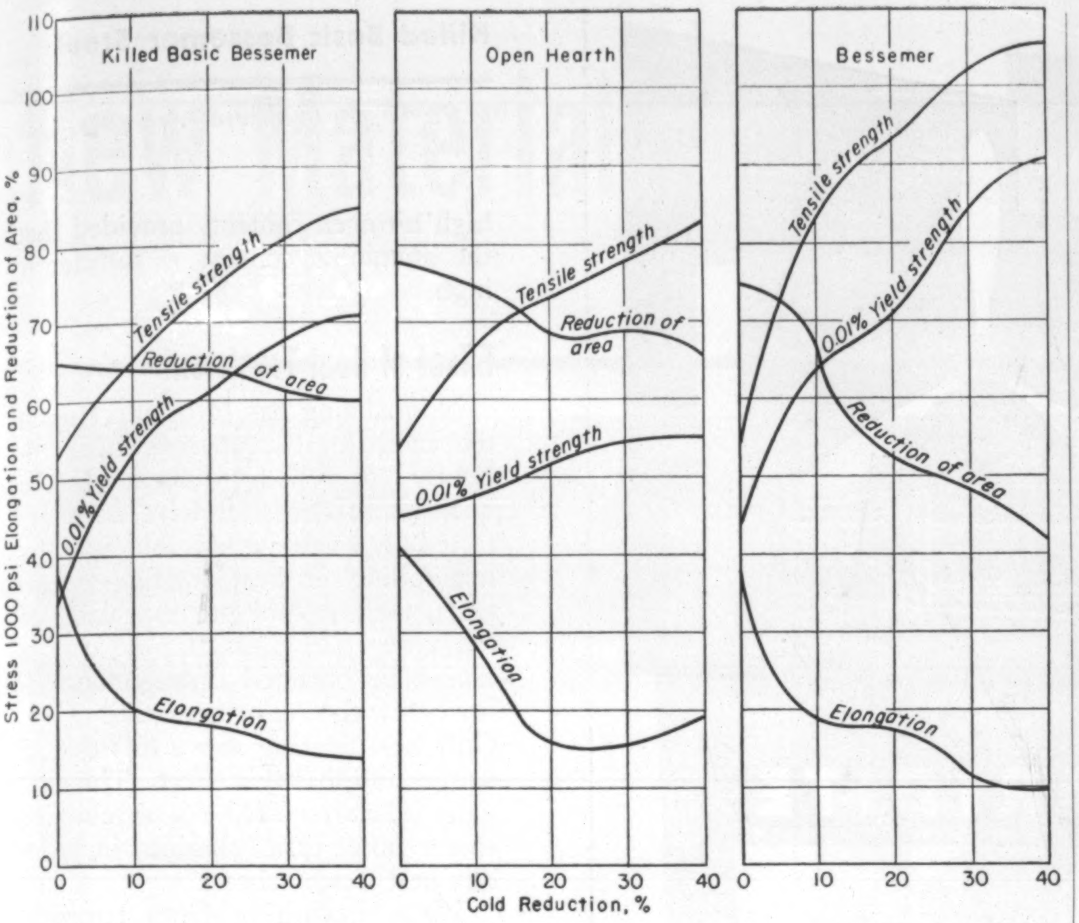
Killed Basic Bessemer Steel Has Good Cold Forming Qualities

by HUBERT HAUTTMANN, (Translated from the German by H. J. Pessl)

• THE COMMERCIAL PRODUCTION of a low manganese aluminum-deoxidized basic Bessemer Steel was started in Germany in 1943. This steel was developed for severe deep-drawing operations and resembles basic open hearth steel more closely thang normal Bessemer Steels.

The principal fields of application for the low-carbon, low-manganese basic Bessemer steel are cold heading rounds for all purposes, strips and sheets for the most severe deep drawing operations, sheets for cold pressing in thicknesses up to 0.6 in. and bars for difficult, high quality cold forming operations. This steel has not only proven its ability to replace common open-hearth steels in these fields of applications, but even some special types of open-hearth steels.

The composition of the steel is 0.03 to 0.1 carbon, 0.1 to 0.2 man-



Effect of cold work by drawing on properties of low-carbon, low-manganese killed basic Bessemer, open hearth, and normal basic Bessemer steels.

Mechanical Properties

Shape	Size, in.	Yield Strength, psi	Tensile Strength, psi	Elongation L = 10D %	Reduction of Area %	Cupping Test mm	Impact Strength Mkg/Sq Cm	
							Unaged	Strain Aged
Bar[1]	3	34,000	50,000	32	82	—	29	2
Rod[1]	2.4	36,000	53,000	28	75	—	24	1.5
Plate[1]	0.8	37,000	52,000	28	75	—	27	1.5
Sheet[2]	0.2	40,000	57,000	29	—	18	—	—
Sheet[2]	0.04	30,000	47,000	37	—	11	—	—

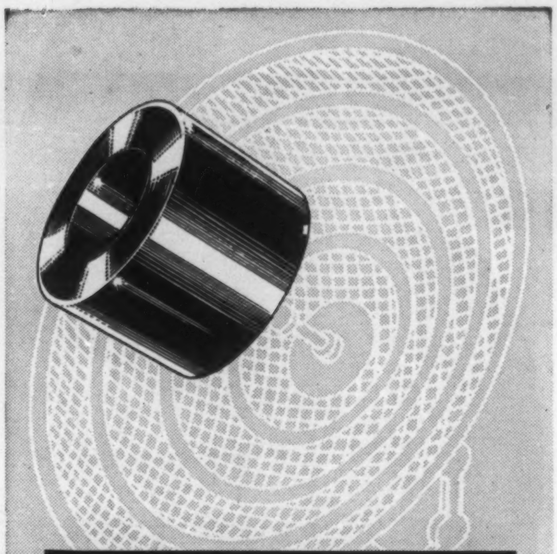
[1] As-rolled
[2] Annealed

---

ganese, 0.012 to 0.020 nitrogen, a minimum of 0.02% soluble aluminum (metallic) with a maximum of 0.08 silicon, 0.05 phosphorus and 0.04% sulfur.

Typical mechanical properties are given in a table. The tensile strength of this new steel ranges from 47,000 to 57,000 psi and is comparatively low for air refined converter steel. The elongation values are high even for the thicker rolled profiles. High values of reduction of area and of the cupping test indicate good cold forming qualities. The notch toughness as determined by the modified DVM—key-hole notch bar impact test in the unaged and strain aged condition, ranges within the same limits as that of comparable open-hearth steels. If properly heat treated the steel can be made aging resistant even with

(*Continued on page 144*)



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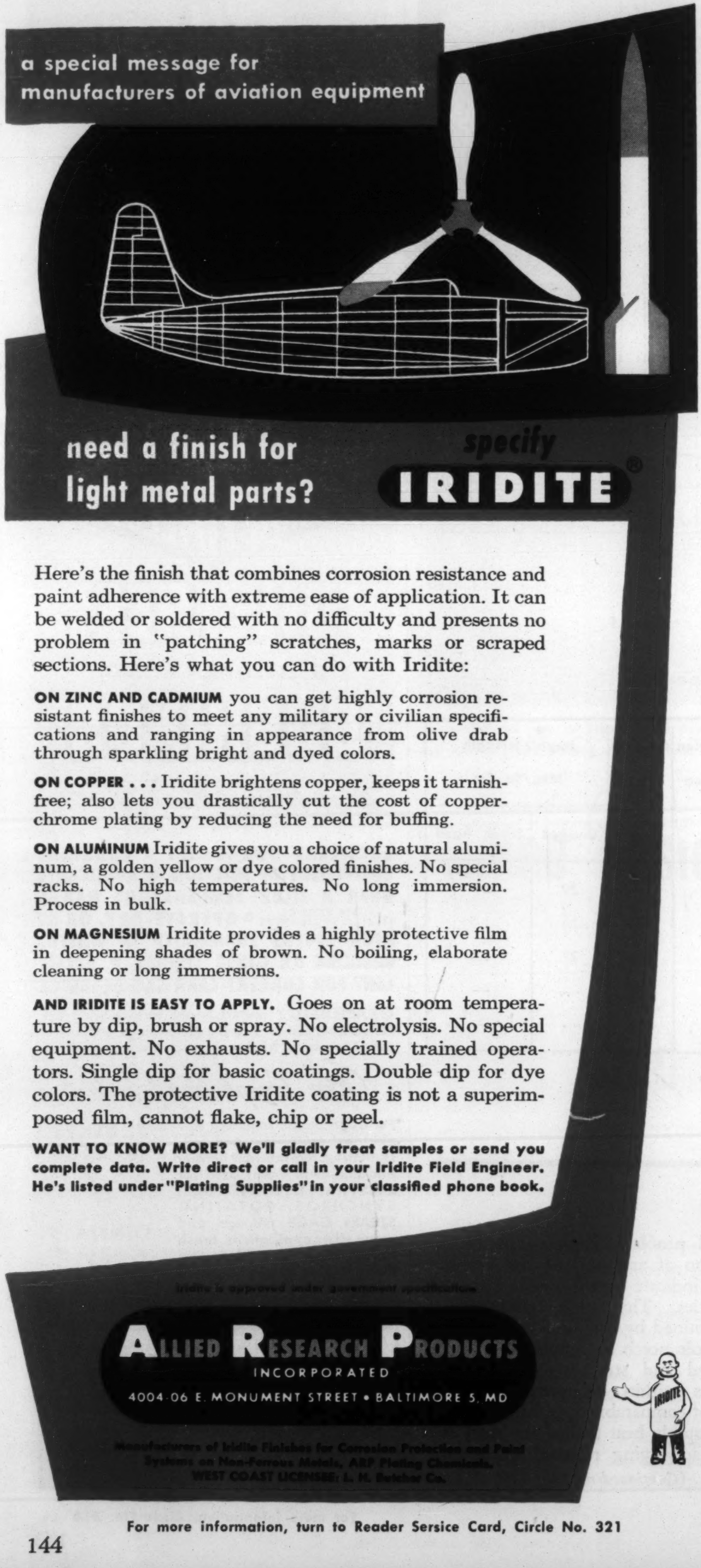

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(continued from page 143)

high nitrogen contents provided that the aluminum content is sufficiently high.

Effect of Heat Treatment

Normalizing has little effect upon the mechanical properties of sufficiently hot rolled products. If the qualities of the steel have been affected in some undesirable way by hot rolling or heat treating operations, their restoration, especially of the elongation and cupping values cannot be obtained through annealing below the A_{c3}-temperature range. Only heat treating above this critical temperature has this effect. The cupping values required for automotive sheets can be easily obtained in properly heat treated sheets.

Water quenching from temperatures above A_{c3} increases the yield strength more than the ultimate strength. The elongation is decreased, while the reduction of area is considerably improved. In the water quenched condition the steel is resistant to aging embrittlement.

Comparison with Other Steels

The effect of cold working by drawing upon the tensile properties of soft low-carbon, low-manganese steel in the as-rolled condition are shown in a figure. For comparison, the results obtained with soft, killed openhearth steel and with a normal basic Bessemer steel are plotted also. The tensile strengths of the steels in their original condition were practically of the same magnitude. It can be seen from the figure that the changes in the tensile properties of the new steel, due to cold deformation, are nearly the same as those of the open-hearth steel. The properties of the Bessemer steel are quite different.

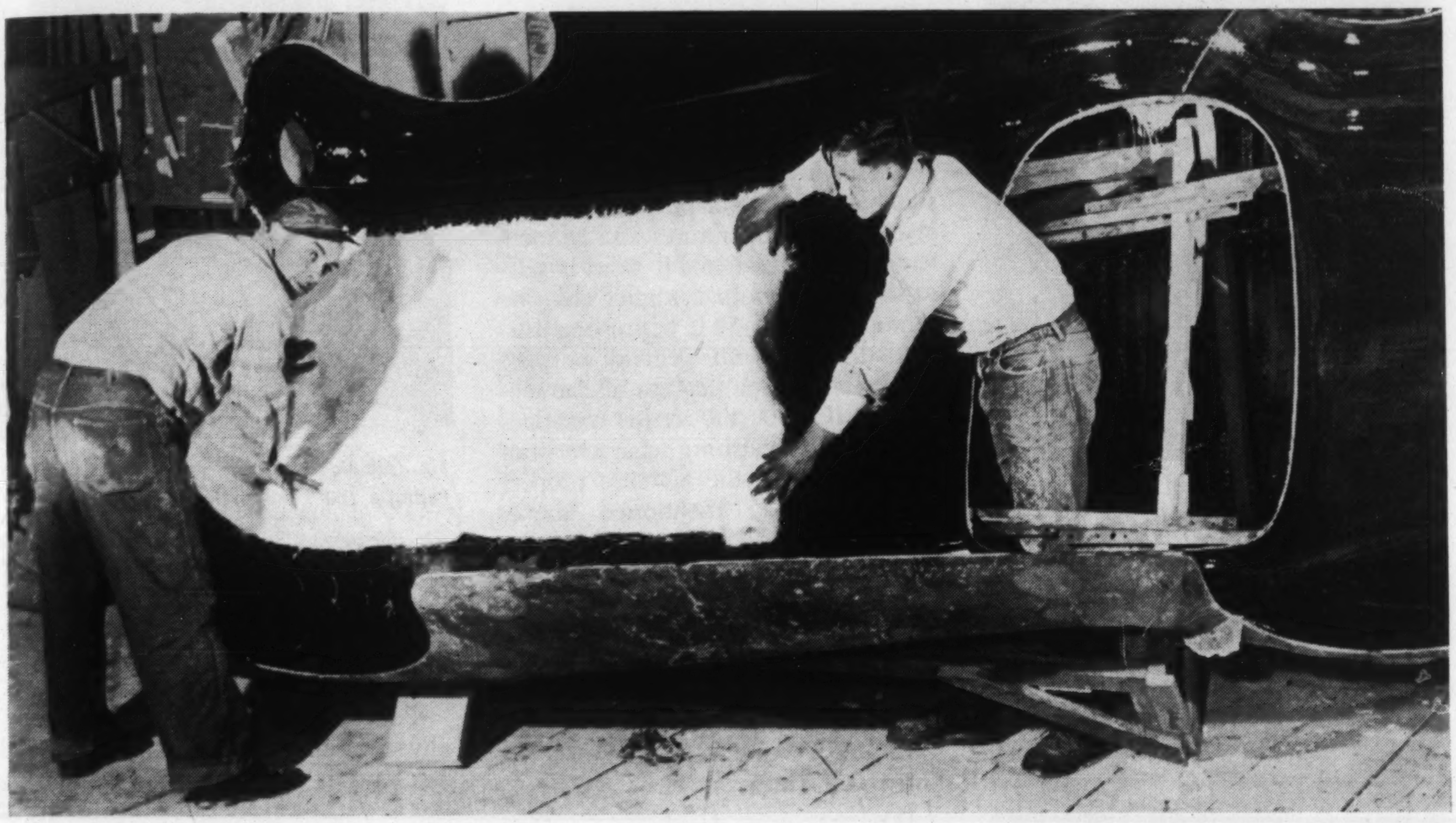
Recovery and recrystallization properties of the killed steel are similar to those of other deep drawing steels. The new steel shows considerable improvement over common rimmed basic Bessemer steel.

Thousands of tons of the killed basic Bessemer steel have been used in Germany in applications requiring severe cold forming with results similar to those obtained with open-hearth deep-drawing steels.

Translated and abstracted from *Verein Deutscher Eisenhuttenlevte.*

New Materials, Parts and Finishes

. . . and Related Equipment



The use of glass fiber reinforced polyester resins for car bodies has been receiving increased interest from automotive manufacturers.

A Roundup of Recent Reinforced Plastics

● At this point in the growth of the plastics industry, the emphasis in materials development is turning away from new and radically different types of resins. The research and development work is concentrating more heavily on refinement of existing types of resins to produce properties lacking in available materials or to improve weak properties which limit the use of plastics in certain applications.

Recently there have been many resins developed to improve materials for reinforced plastic use. Some have not previously appeared in these columns. This is the first of a two-part roundup series on these resins, to acquaint you with them, and to indicate generally where they fit in the plastics materials picture.

1-General Purpose Resins

The polyester resins are the most widely used resins in the field of reinforced plastics today. Most of the general purpose resins mentioned below are polyesters, developed to overcome one or more of the shortcomings inherent in resins of this type previously available.

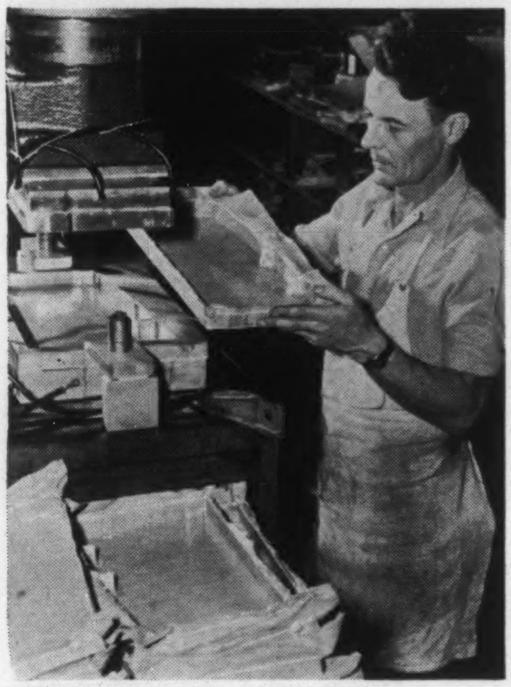
Air Uninhibited

Air inhibition, sometimes occurring during the cure of polyester resins has usually been overcome by the addition of a metallic salt drier. Recently three air uninhibited polyesters were developed which cure in contact with air, regardless of the mass involved.

Glidpol 1002, produced by the *National Glidpol Lab., Glidden Co.,* 1855 N. LeClaire Ave., Chicago, coreacts with oxygen to provide a cured surface possessing a high Barcol hardness rating, good abrasion resistance, and insolubility in acetone. When laminated, any air trapped between the laminates aids the curing of the inner surfaces, and eliminates the need for sealing the edges of the laminate.

Advantages claimed for the material are: short curing cycles of 1 to 2 min at 300 F, high degree of binding and stiffening of fluffy preforms, no discoloration of binder during cure, and since the binder cures thoroughly in the presence of air, it exhibits no tack at elevated temperatures and preforms can be handled without difficulty while hot.

IC-625 Resin, developed by the



Drawing resin-impregnated mat into a mold makes simple, shallow parts.

Interchemical Corp., 67 W. 44th St., N. Y. was designed to fill the need for a resin which, at room temperature, will cure tack-free in the presence of air. It can be used for the preparation of an emulsion binder for glass fibers as well as for general fabrication.

It has a relatively short cure time and a good pot life. Peak exotherm temperature is moderate, and the cured resin is said to have good physical properties. It has a heat distortion point of 86 F at 264 psi as sold.

The resin is suitable for heated matched metal molding and for hand lay-up work. It is said to be particularly suitable for such applications as boat covering, tanks, and other constructions where process limitations prevent exclusion of air from all the resin surfaces during curing.

Plaskon Resin 9500, developed by the *Barrett Div., Allied Chemical & Dye Corp.*, P.O. Box 27, Station 1, Toledo 14, will also dry tack free in contact with air. It was designed specifically for applications where increased impact and fatigue strengths are desired.

According to the company, it presents in a single resin the effect of a blend of rigid and flexible type polyester resins and results in high quality surface characteristics with a minimum of warping and crazing. It is said to have most of the physical characteristics of a general purpose resin, although due to its lower heat distortion point, it should not be used where elevated temperatures will be encountered.

Self-Extinguishing

Three experimental unfilled fire retardent polyester resins have been developed for general and special applications by the *Interchemical Co.*, 67 W. 44th St., N. Y. IC-594 FR resin is a self-extinguishing resin suitable for general purpose molding at elevated temperatures and at room temperature. IC-636 FR resin is self-extinguishing with a higher chlorine content than IC-594, permitting further dilution with general purpose resins for varying degrees of flammability. IC-670 FR resin combines the self-extinguishing characteristics of IC-594 with the air cure properties of IC-625 mentioned above. This resin lends itself to room temperature, air exposed cures where a tack-free surface is necessary and where the material must be self-extinguishing. Limited quantities of these chlorinated polyesters are available for experimental use.

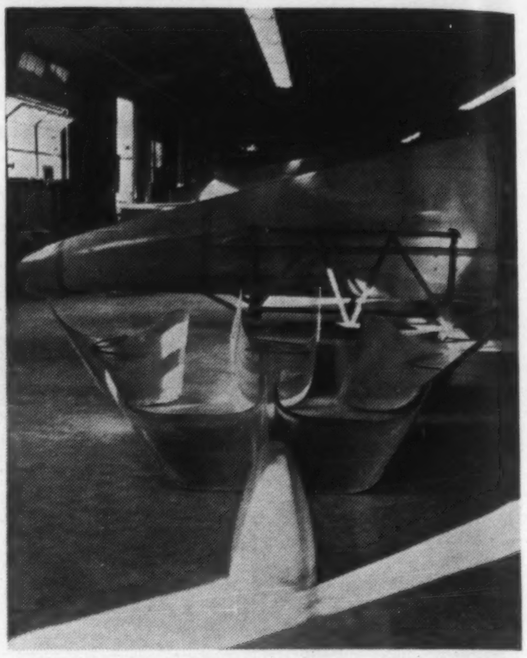
Short Gel Time

DX-292 resin, developed by *U.S. Industrial Chemicals Co. Div., National Distillers Prod. Corp.*, 290 Doremus Ave., Newark 5, due to its short gel time (3 to 5 min), is particularly suitable for use where vertical lay-ups are encountered. It is a light colored, medium viscosity polyester resin which can be cured at room temperature with the use of cobalt and methyl ethyl ketone peroxide.

The resin is also said to have high chemical resistance for use in fume ducts, tanks, and reactors, and a light-stable modification can be used in the manufacture of corrugated sheeting. A sytrene resin, DX-373, developed by the same company, can be blended with DX-292 to add a high degree of flexibility and impact strength.

Thixotropic Polyesters

The *Marco Products Div., Celanese Corp. of America,* 1711 Elizabeth Ave., West Linden, N. J., has recently marketed several thixotropic resins, i.e., tending to solidify at rest, but liquify when agitated. Marcothix #1 is a rigid, general purpose resin supplied in a consistency of light lubricating grease, which due to its thixotropic nature, can be applied to vertical or overhead surfaces without drainage, sagging or run off.



Six plastic sections make up airplane "stinger tail" shown in background.

For ease of handling, it is generally recommended that catalysts and accelerators be added by mixing them with a general purpose rigid resin and then blending with Marcothix.

Marcothix #2 is a thixotropic flexible resin designed primarily for modification of #1 to provide increased flexibility.

Marcothix #3 is a semi-rigid resin with the same thixotropic characteristics as #1, but which is finding applications where a medium degree of flexibility is required.

High Heat Distortion Point

MR-33C resin, also developed by Marco Products is a rigid resin containing approximately 25% chemically bound chlorine. The presence of the chlorine greatly reduces the burning rate of the resin and increases the heat distortion point (to about 245 F). The viscosity is approximately 1500 cps. Two other resins have been developed by the company with essentially the same properties as MR-33C, only in higher viscosities. MR-33H has a viscosity of 30,000 to 40,000 cps and MR-32 has a viscosity of approximately 1,000,000 cps.

Picture credits: U.S. Rubber Co., Republic Aviation Corp., Zenith Plastics.

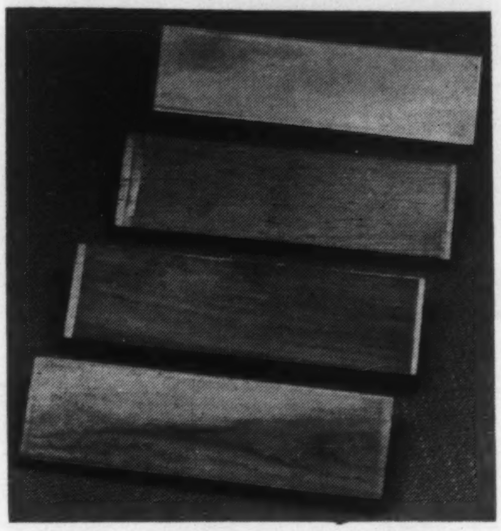
Silicone, Phenolic Join in New Base for Protective Coatings

Copolymers of silicone and oil-modified phenolic resins have been developed to serve as a new class of vehicles for protective coatings. They are designed to supplement conventional phenolic resins for applications where added resistance to heat, weathering, chemicals and moisture is needed.

Developed by *Dow Corning Corp.*, the first two materials now available in laboratory quantities are known as XR-875 and XR-859 and contain 25 and 50% silicone respectively. According to the company, spar varnishes based on XR-875 show a high degree of color retention after 1000 hr in a sunshine weatherometer, while those formulated with XR-859 not only hold their color, but also retain 90% of their original gloss.

Identical in appearance and application to standard phenolic varnishes, both silicone-phenolics air dry to a hard film in 16 hr or less. The water and chemical resistance of the films is said to be better than comparable silicone alkyds. They can be baked to give good film properties in the 400 to 500 F range. Soluble in mineral spirits, they are compatible with alkyd and phenolic varnishes.

The properties of the materials suggest their use in spar varnishes, maintenance paints and specialty coatings.



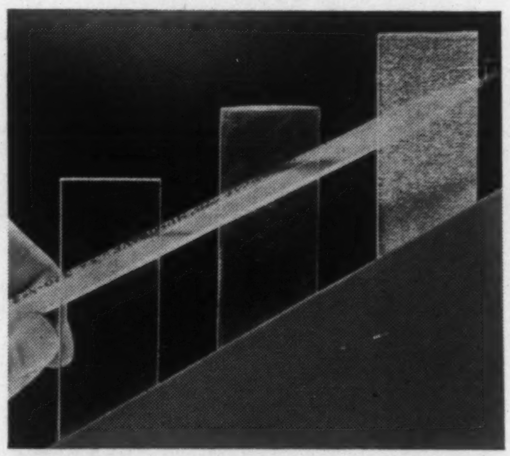
Specimens after 1000 hr in Weatherometer. From the top: control, phenolic based, XR-875 based, and XR-859 based varnishes.

Cellulose Acetate Butyrate Withstands Weathering

A new formula of Tenite butyrate plastic has been developed for outdoor use by the *Eastman Chemical Products, Inc.*, Kingsport, Tenn.

Sheeting extruded from the material is said to have high resistance to outdoor exposure while retaining the advantages of ease of vacuum forming and high strength in thin sections. Vacuum formed sheets of the material can be fastened tightly to metal frames, and the material is said to have a resiliency which absorbs thermal expansion and contraction.

Sample sheeting extruded from the new formula has been company tested under continuous exposure to weather over a three year period with good results.



Left, 0.075-in. specimen before exposure; center and right, new and old material after 32-mos exposure.

New Molding Phenolic Speeds Cure Time

A new phenolic plastic with a greater versatility and faster cure time to speed production of molded parts has been developed by the *Bakelite Co.*, 30 E. 42nd St., New York 17.

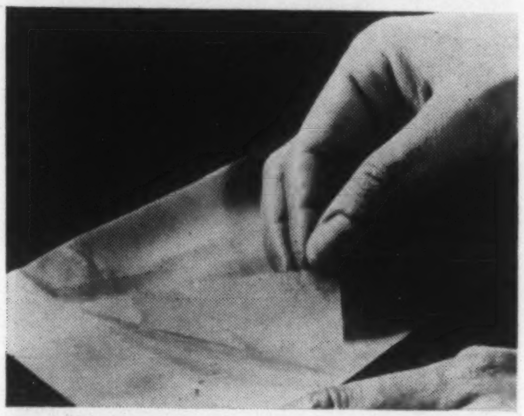
The characteristics of the BMG-5000 resin are said to eliminate the need to buy and store many different compounds for differing mold and molding requirements, and to combine desirable properties and appearance in one material.

BMG-5000 allows longer preheating at higher temperatures and fills out molds at lower pressures than other general purpose phenolic molding plastics, according to the company. It also has good rigidity at hot discharge from the mold, allowing the maintenance of critical tolerances and ensuring free release of the molded piece.

The high speed of cure is obtained with compression, transfer and plunger type molding as well as with other molding techniques, and the physical, chemical and electrical properties of the material are said to at least equal those of other materials of the same type.

The resin has a wide latitude of plasticity and produces molded pieces with high dimensional stability, machinability, and a gloss finish free from haze and surface defects.

Two Adhesives Bond Polyester Film



After 30 min at 250 F a fiber-tearing bond is retained between Mylar and paper with Bondmaster L440 adhesive.

Two new adhesives designed for bonding Mylar polyester film (M&M March 1954, p. 104) to a range of papers, plastic films, fabrics, etc., have been marketed by *Rubber & Asbestos Corp.*, 225 Belleville Ave., Bloomfield, N.J.

High Dielectric Strength

Bondmaster L272, said to have high dielectric strength, is designed to retain full bond strength after constant exposure to temperatures in the range of 320 F. It is expected to find applications in the manufacture of laminations used in slot insulation, phase insulation, motors, and core and layer insulation in transformers.

Sterilization Resistance

Bondmaster L440 was developed for bonding Mylar to paper for sterilization resistant applications and is said to retain its fiber-tearing bond without discoloration after 30 min exposure to live steam at 250 F. This resistance to hydrolysis is said to eliminate softness and delamination which are often found when conventional formulations are similarly sterilized.

Large Diameter Tubing and Ducting of Rigid PVC

Rigid polyvinyl chloride tubing and ducting with 6, 8, 10, and 14-in. i.d. are being marketed by the *Kaykor Industries, Inc.,* Yardville, N.J. Furnished in 4-ft lengths and trade marked Vyflex, the piping and tubing are produced of unplasticized and unmodified PVC by a process refined by the company.

The high degree of chemical resistance and the good physical properties of the material are retained in the Vyflex tubing and ducting, making them useful where severe corrosive conditions prevail and where large diameter sections are required, such as in waste systems, exhaust ducts and feeder lines.

Pure Magnesia Refractory Now in Quantity Production

A magnesia refractory material, approximately 97% pure, can now be made in production quantities and in such large industrial shapes as furnace linings and bricks weighing several hundred pounds.

The new method of manufacture, developed by *Electro Refractories & Abrasives Corp.*, Buffalo, N.Y., is said to utilize much lower temperatures than those used previously, allowing manufacture in almost any commercial size.

According to the company, the new refractory is more spall resistant than non-crystalline magnesia refractories and less likely to contaminate materials being processed.

Applications for the new material are expected to lie in the chemical field for the processing of molten salts and lime and the manufacture of calcium carbide, in the metals field where resistance to basic slags or metals is required, and in the lead industry for smelting and purifying operations.

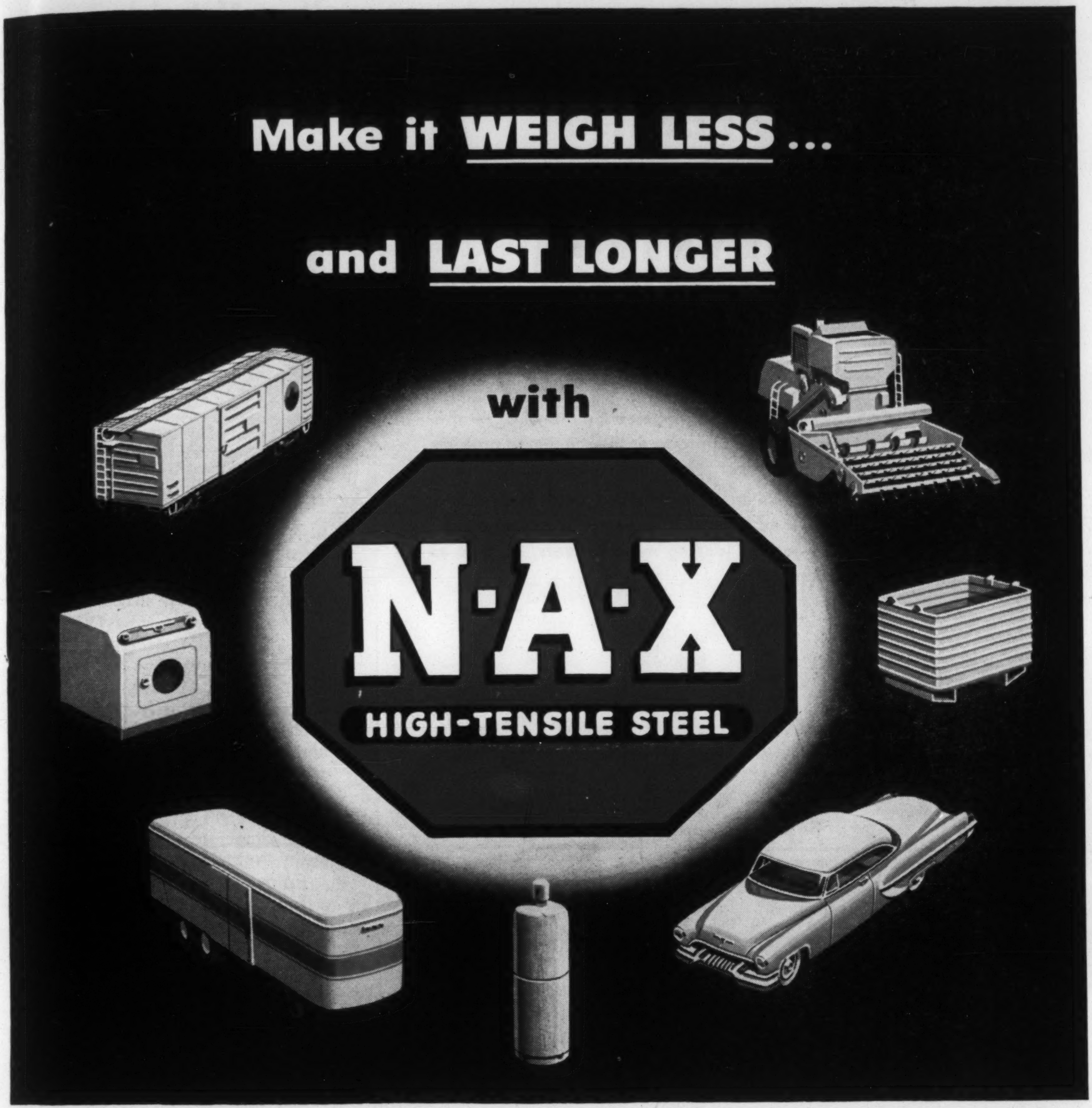
Controlled Cooling Power With New Quenching Oils

A new series of quenching oils which is said to closely control the heat dissipation of quenched metals to prevent cracking, pitting, distortion and warpage has been marketed by the *Sinclair Refining Co.,* 600 Fifth Ave., N.Y.

According to the company the new oils, known as the Sinclair Quenchol 500 Series, by providing increased cooling power assure a uniform degree of metal hardness as well as an improved depth of penetration. Company tests indicate the new oils will enable metal working plants to utilize lower cost steels for critical purposes.

Other features claimed for the Quenchol 500 series are minimum oil evaporation and drag-off, together with prolonged service life due to improved resistance to deterioration and breakdown.

(Continued on page 152)



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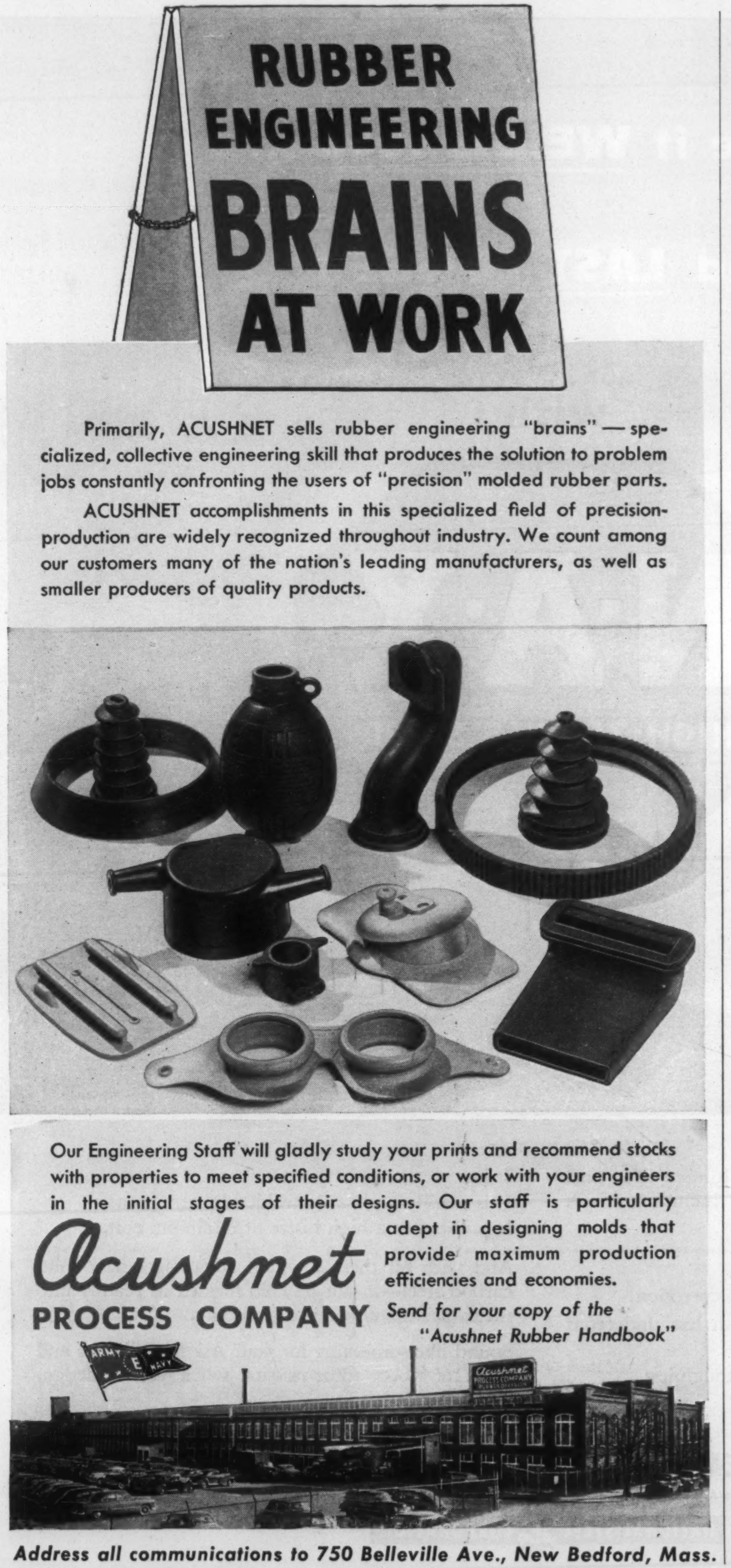

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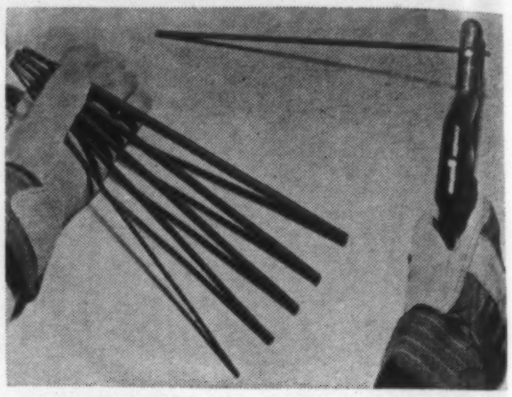
New Electrodes: Hardfacing, Metal Coated, Bronze



Hardfacing

A new series of general service, iron-based d.c. hardfacing electrodes of a chromium, boron and iron composition has been marketed by the *Wall Colmonoy Corp.,* 19345 John R St., Detroit 3.

They are available in two types. Colmonoy No. 1 deposits are said to have a hardness of Rc 58 to 63, with high impact resistance and weldability, good abrasion and erosion resistance and red hardness. It has a specific gravity of 7.70 and melts at 2400 F. Typical applications include dipper teeth, bucket lips, drag chains, mill hammers, etc.

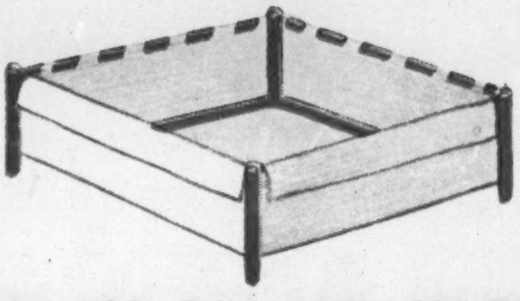
Colmonoy Special No. 1 alloy has a hardness of Rc 60 to 65, with higher abrasion resistance and weldability, yet good impact and erosion resistance and red hardness. It has a specific gravity of 7.55 and melts at 2450 F. Typical applications include ash plows, fan blades, coal and coke chutes, etc.

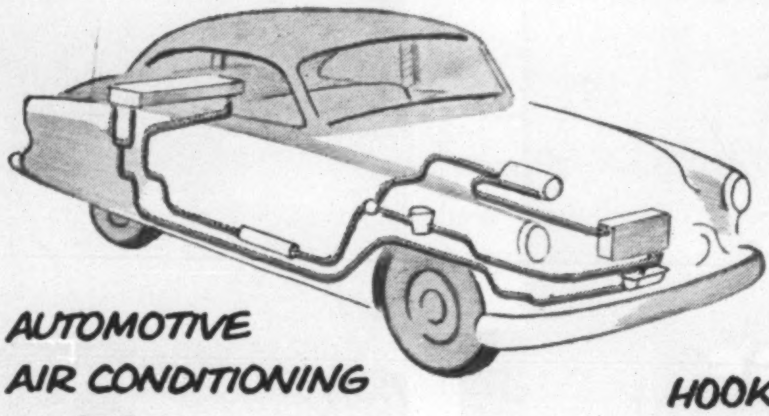
Both electrodes are said to provide dense deposits that do not require cleaning or slag removal by chipping or brushing before welding on successive deposits.

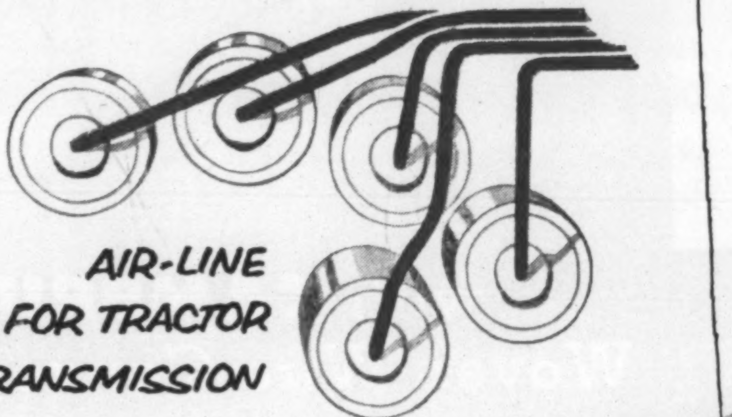
Metal Coated

The second in a series of electrodes which incorporate powder metal in their coatings has been developed by *Lincoln Electric Co.* 22801 St. Clair Ave., Cleveland 17. The new electrode, called Jetweld 2, is designed for welding butt and deep groove joints whereas Jetweld 1 (M&M, Dec. 1953, p. 182) was designed for welding horizontal and flat fillet joints. According to the company, the new electrode is designed for high speed welding at the lowest possible cost per foot of weld with easy slag removal, good physi-

FROM *the Bundy Sketchbook* TO *jog a designer's imagination*


FRAME FOR DOG-AND-CAT BED

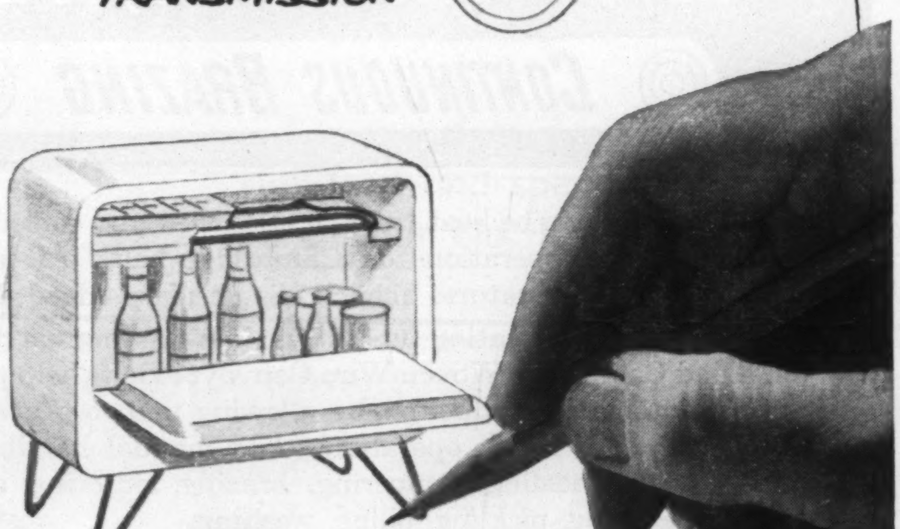

AUTOMOTIVE AIR CONDITIONING LINES


AIR-LINE HOOKUP FOR TRACTOR TRANSMISSION

REMARKS Maybe you demand tubing versatility above all else. Or maybe durability is more important to your product. Whatever your fabrication or performance requirements, you can rely on Bundyweld, the only tubing double-walled from a single strip. Added bonus: Bundy's expert engineering services, unexcelled fabrication facilities.

WRITE today for information or for help in developing your tubing ideas.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN


COILS FOR PORTABLE REFRIGERATORS

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness,

and passed through a furnace. Copper coating fuses with steel. Result . . .

SIZES UP TO ⅝" O.D.
Bundyweld, double-walled and brazed through 360° of wall contact.

BUNDYWELD TUBING®

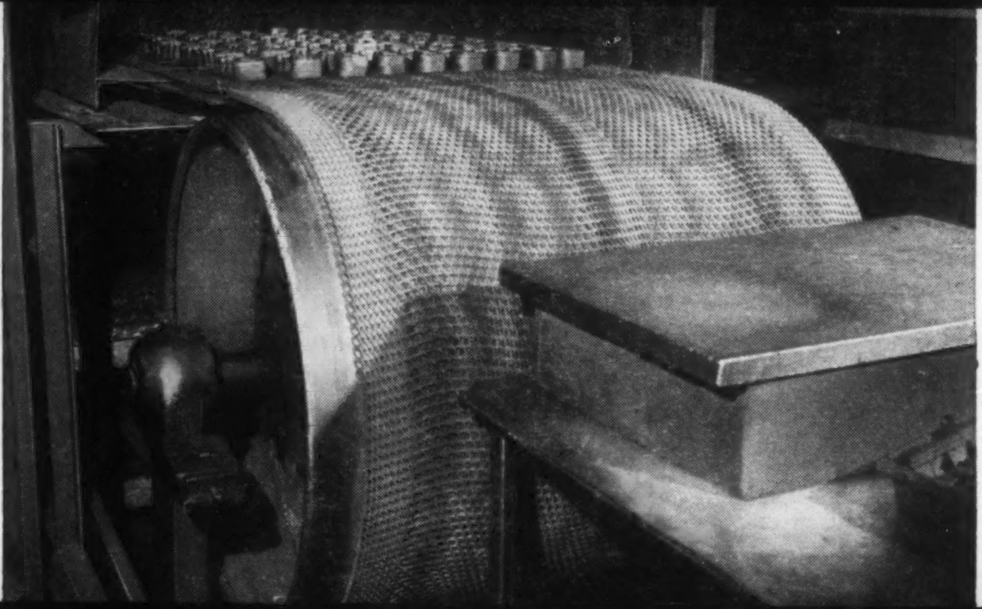
DOUBLE-WALLED FROM A SINGLE STRIP

- Leakproof
- High thermal conductivity
- High bursting point
- High endurance limit
- Extra-strong
- Shock-resistant
- Ductile
- Lightweight
- Machines easily
- Takes plastic coating
- Takes plating
- Bright and clean
- No inside bead
- Uniform I.D., O.D.

Bundy Tubing Distributors and Representatives: *Bridgeport, Conn.:* Korhumel Steel & Aluminum Co., 117 E. Washington St. • *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Los Angeles 58, Calif.,* Tubesales, 5400 Alcoa Ave. • *Philadelphia 3, Penn.:* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South • *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 181 Fleet St., N.
Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

For more information, turn to Reader Service Card, Circle No. 330

idea for AUTOMATION

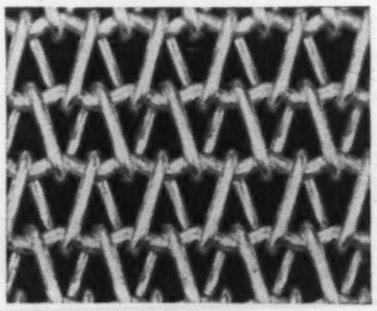


with **CAMBRIDGE**
Woven Wire Conveyor Belts

CONTINUOUS BRAZING

Metal products can be heat treated, quenched and cooled in one continuous series of operations on Cambridge belts. All-metal belt is unharmed by temperature, quench oils or sharp-edged, heavy loads.

If you're still heat-treating by costly, time-wasting batch operations you'll find Cambridge Woven Wire Conveyor Belts help provide cost-cutting, automatic production by allowing you to process the work *continuously*. No batch operations, less manual handling for such processes as: annealing, tempering, brazing, sintering, soldering, as well as quenching, pickling, oiling, washing.



OPEN MESH CONSTRUCTION of the belt provides free circulation of heat-treating atmospheres for uniform processing, free drainage of process solutions. Of course, the all-metal construction means lowest maintenance cost.

CAMBRIDGE BELTS are available in any metal or alloy. Thus, the belt recommended for you can be fabricated from the specific material that will give longest belt life under your operating conditions. In addition, Cambridge belts can be woven to any length or width and in a wide variety of weaves and mesh sizes to meet your needs.

FREE REFERENCE MANUAL gives full details on how Cambridge belts can boost output, cut costs by providing continuous, automatic production . . . *automation!* Includes all specifications and details, also metallurgical tables. Write for your copy today! Or, for specific recommendations, call in your Cambridge Field Engineer. He's listed under "Belting-Mechanical" in your classified 'phone book.

Cambridge
CONVEYOR BELTS

The Cambridge Wire Cloth Co.

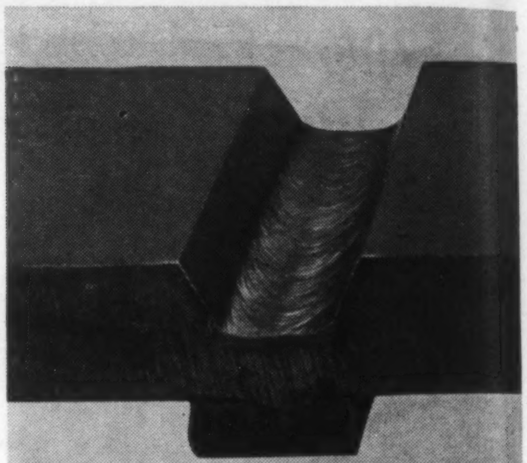
WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

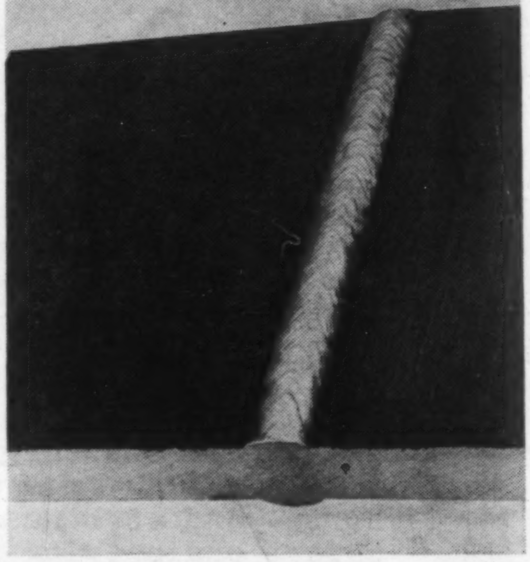
Department A
Cambridge 6, Maryland

OFFICES IN LEADING INDUSTRIAL AREAS

For more information, turn to Reader Service Card, Circle No. 432

New Materials, Parts and Finishes





cal properties, smooth appearance and low crack sensitivity.

The powder metal in the coating acts both as an additional source of weld metal, and a limiting factor on the heat in the arc. It is operated with a drag technique and is said to provide good wash-in and slag removal with a minimum of spatter.

Typical physical properties are: yield strength, 55,000 psi; tensile strength, 66,000 psi; elongation as-welded, 28%; stress relieved, over 30%; and Charpy keyhole notch impact values average 37 ft lb at room temperature.

Bronze Electrode

An electrode producing copper base deposits alloyed with silicon, manganese and chromium has been developed by *Eutectic Welding Alloys Corp.*, 40-40 172 St., Flushing, New York.

Designated EutecTrode 1850, the electrode is said to provide deposits with Brinell hardnesses of 130 to 140, good tensile strengths, and high

SPENCER
HARTFORD

TURBOS

FOR SPECIAL OCCASIONS

Standard motor driven Spencer Turbos are listed in more than 160 sizes. For special applications, there are many variations, six of which are illustrated.

Spencer Turbos range in size from 35 to 20,000 cu. ft. per min. 4 oz. to 10 lbs. and 1/3 to 1,000 h.p.

For complete description of the standard and special Turbos ask for Bulletin No. 126-A.

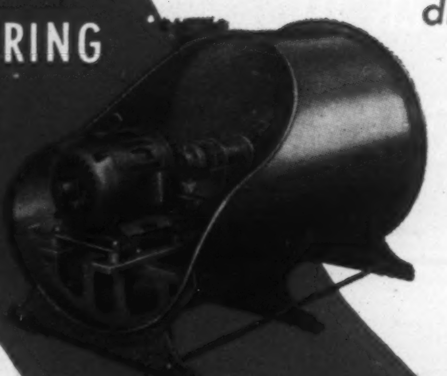
MIDGET

With universal motor, 35 to 75 cfm at 12 to 40 oz. pressure

GAS BOOSTER

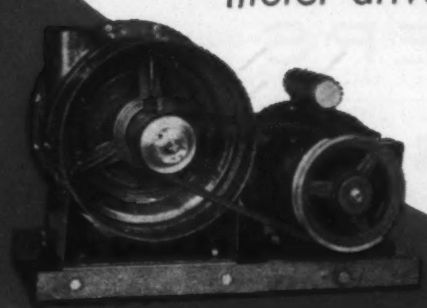
For handling gas, acid fumes, poisonous, corrosive or explosive gases

4 BEARING



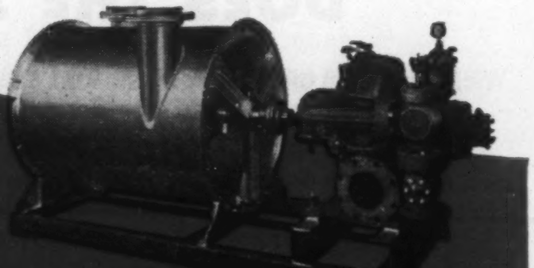
Overhang or outboard type for coupled drive

BELT DRIVE



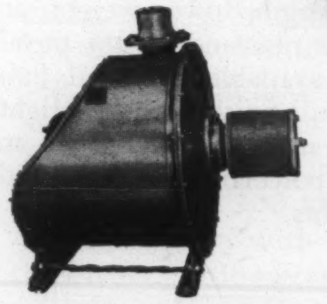
For odd frequency or other than electric motor driven

TURBINE DRIVEN



For use where it is desired to operate with steam

AIR FILTERS

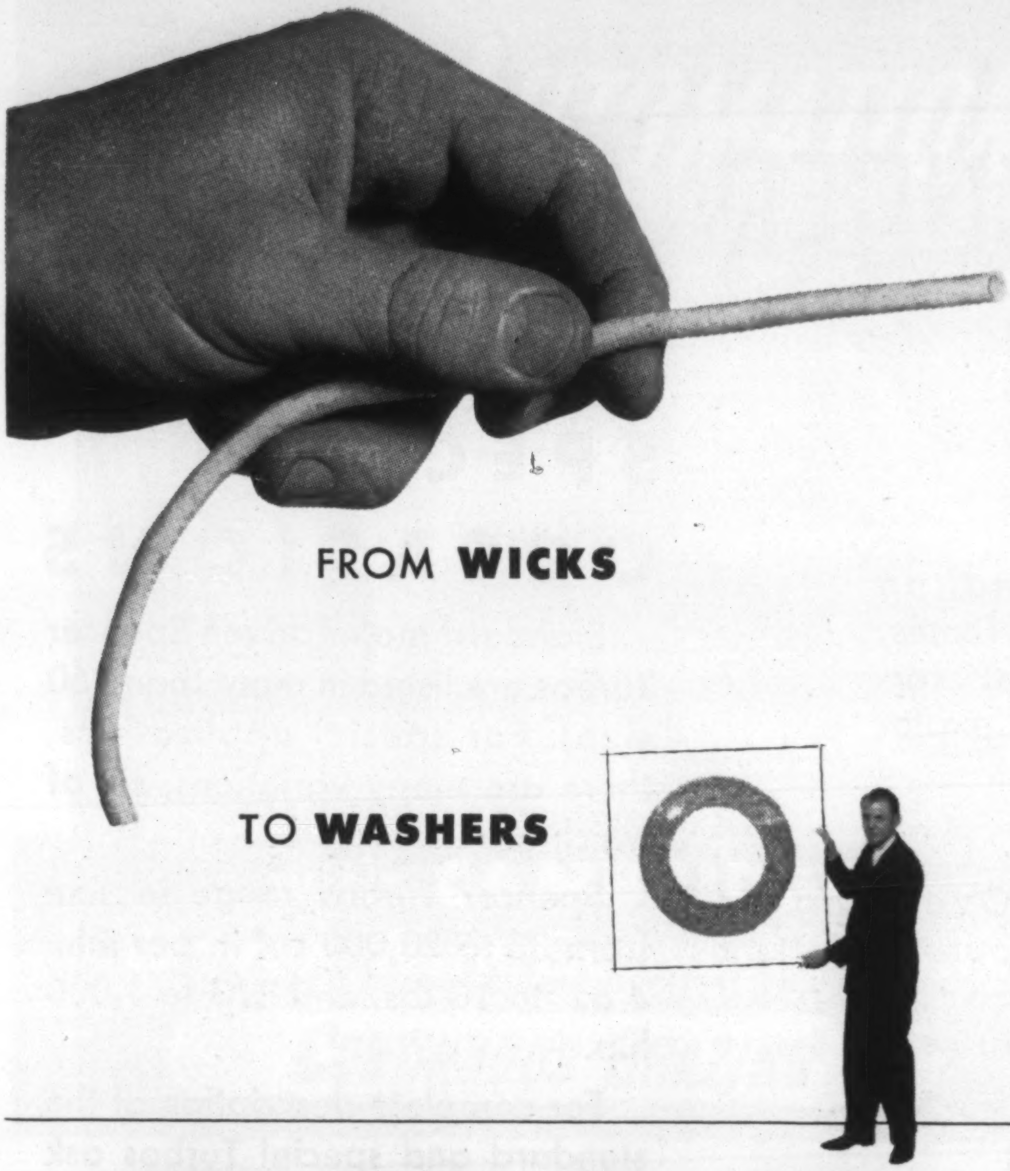


Of various types for intake of Turbo

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER
HARTFORD

For more information, turn to Reader Service Card, Circle No. 318



FELT
by FELTERS

DOES THE JOB RIGHT

Wicks that pull oil in — washers that keep dirt out — are two of many jobs done by Felters Felt, to keep equipment in good operating condition.

Hard enough to be ground and chiseled, soft enough to buff a jewel — or any texture in between — each shipment of Felters Felt is uniformly controlled to exactly meet your specs.

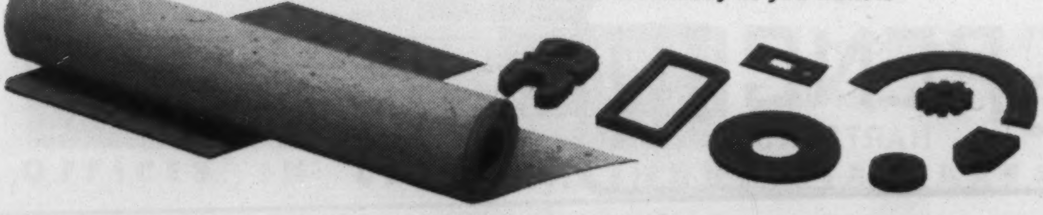
The "Felters Design Book" contains interesting information about several grades of Felt and their uses. We will be glad to send you a copy. Write today. THE FELTERS CO., 220 South St., Boston 11, Mass.

FELTERS S.A.E. F-1 FELT is a grade suitable for oil retention where the felt is not compressed, for feeding light oil, or where unusual strength and hardness are required. Often recommended for use in resisting wear and abrasion.

This is one of many grades of Felters Felt produced for specific applications.

FELTERS FELT

. . . by the roll . . . by the yard
. . . or cut exactly as you want it

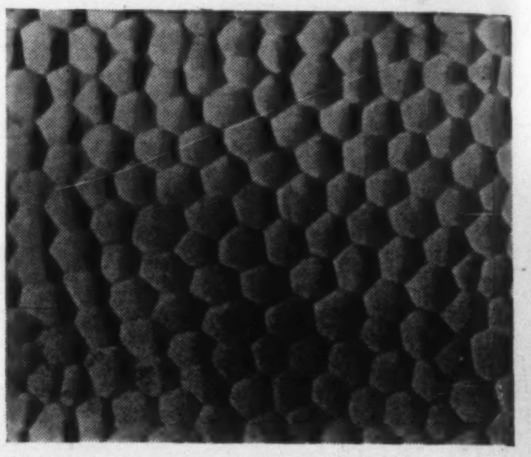


For more information, turn to Reader Service Card, Circle No. 353

New Materials, Parts and Finishes

friction and corrosion resistance.

The electrode is recommended for joining and overlaying steel, cast iron and copper alloys, and for various combinations of ferrous and nonferrous metals including stainless steel, nickel and nickel alloys.



New Pattern for Textured Metal

A new pattern in textured ferrous and nonferrous metals has been marketed by the *Rigidized Metals Corp.*, 660 Ohio St., Buffalo 3, N. Y.

Designated 1-HM the hammered metal pattern has a maximum depth of 0.025 in. on sheets up to 0.0312 in. thick in stainless steel, copper, brass and aluminum. It is said to increase strength, lower weight, and increase mar resistance of the metals.

Finishes available are, mill finish as rolled, mill finish with highlights, colorized and highlighted, and painted or porcelain enameled without highlights.

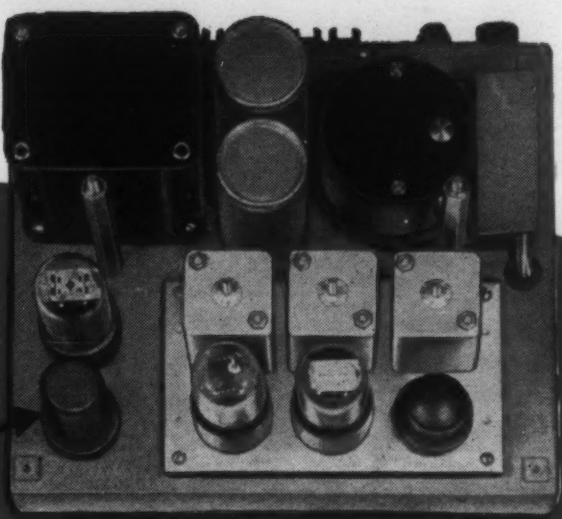
No Hardeners Needed for New Epoxy Resin

A new epoxy resin intended for casting, potting, and laminating and which requires no toxic hardeners for curing has been marketed by *Furane Plastics, Inc.*, 4516 Brazil St., Los Angeles 39. The new resin, called Epocast III is also said to have better heat resistance than other low temperature curing epoxies.

It is available as an unfilled, transparent resin with a yellow caste. It is cured in 1 to 3 hr at temperatures

New WESTON Inductronic® D-C AMPLIFIER

Measures Millivolts to 0.1%!...



The new Weston Inductronic D-C Amplifier measures both millivolts and microamperes to an accuracy previously unheard of. A product of Weston Electrical Instrument Corp., Newark, N. J.

The Weston Resistance Network (Actual size) is wound with D-H Manganin wire to achieve a high degree of stability with extreme accuracy.

Its resistor network uses D-H ALLOY to assure HIGH STABILITY and ACCURACY

When it's millivolts or microamperes you are measuring, you talk in terms of accuracy in the order of 0.1%. Here is the most accurate measuring instrument yet developed — the Weston Inductronic D-C Amplifier. This amazing instrument makes potential measurements down to microvolts, current measurements to fractions of a microampere.

By using this 200 kc frequency shift amplifier in connection with thermocouples, radiation receivers, bolometers, strain gages, pressure transducers, resistance thermometers, photocells, ionization gages, etc., related physical quantities can be measured with speed and accuracy far superior to any other method previously known.

The amplifying system is essentially an automatic potentiometer, wherein an output current is maintained in balance against the input through a method of accurately adjusted resistors determining the balanced ratio of output to input. With a high gain in the amplification of error unbalance, the accuracy of amplification ratio is of course dependent almost entirely upon the *stability* and *precision* of the resistor network.

For this most exacting function Weston uses Driver-Harris MANGANIN, an alloy of such fixed stability that maximum change in resistance between 15°C. and 35°C. is less than *15 parts per million per degree Centigrade.*

If fixed stability and constant resistance under normally variable operating conditions are "musts" in *your* resistor designs, let us have your specifications. We'll gladly put at your disposal 50 years of alloy manufacturing experience to help solve your problem.

Sole producers of world-famous Nichrome*

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Louisville

In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

*T.M. Reg. U.S. Pat. Off.

MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

For more information, turn to Reader Service Card, Circle No. 320

Forgings
METAL QUALITY
A Reference Book on Forgings
Engineering, production and economic advantages obtainable with closed die forgings are presented in this Reference Book on Forgings. Write for a copy.

combining strength with unmatched toughness, are indispensable to the operation of all types of aircraft

... especially those types that are used for the defense of our country. A product fortified with the metal quality found in forgings outperforms other products. Forgings are used for the toughest work loads. Check all the parts, particularly those which are subject to greatest stress, that make up your product. Check these parts with the aid of Problem Parts Attack Charts which are available upon request. These charts reveal the unrivaled economic and mechanical advantages of closed die forgings and relate them to specific engineering and production problems. Then consult a Forging Engineer about the correct combination of mechanical properties which closed die forgings can provide for your product.

DROP FORGING ASSOCIATION
605 HANNA BLDG. • CLEVELAND 15, OHIO

Please send 64-page booklet entitled "Metal Quality—How Hot Working Improves Properties of Metal", 1953 Edition.

Name ....
Position ....
Company ....
Address ....

For more information, turn to Reader Service Card, Circle No. 462

New Materials, Parts and Finishes

of 150 to 200 F, and large transparent castings can be prepared in one pouring. Shrinkage is claimed to be less than 1%.

As the material is heated during cure, it becomes quite fluid, making it useful as a potting medium for electrical components. It can also be blended with large volumes of fillers for use in color transparencies.

nylaweld
a nylon cement
THE POLYMER CORPORATION
Reading, Pennsylvania
POLYPENCO

Non-Brittle Cement Bonds Nylon Parts

A high strength, non-brittle cement for bonding parts of FM-10001 nylon has been developed by the *Polymer Corp., of Pennsylvania,* Reading. The resulting bonds will not degrade under prolonged exposure to boiling water or boiling concentrated aqueous alkali solutions, according to the company, though complete chemical resistance has not yet been evaluated.

Called Nylaweld, the material is a liquid chemical mixture that produces practically invisible joints. High fluidity permits coating by dipping, brushing, spreading, or spraying. Tensile strengths are said to be only slightly less than the strength of the nylon, varying from 5000 to more than 10,000 psi depending on the cure.

The use of the cement is expected to increase design flexibility and allow the forming and testing of prototype parts without expenditure for dies and molds.

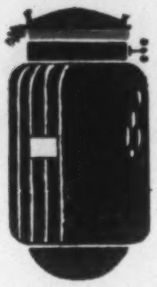
(Continued on page 160)

GET THE FACTS ABOUT FELT AND WHAT IT CAN DO FOR YOU

These are just a few of the many applications of felt in plants and products. Remember that felt is an engineering material, which can be specified as closely as any other. American makes felts as soft as a kitten's ear, or hard as a board, and many other types as well, including OilFoil seals, laminations of synthetic rubber and felt. We also cut felt parts in many shapes, designs and sizes to your blueprints. The Engineering and Research Laboratory will gladly collaborate with you on the selection of the correct felt for maximum economy and satisfaction. Mail the coupon below for further information.

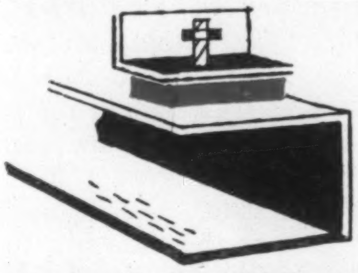
American Felt Company
TRADE MARK

GENERAL OFFICES:
00 GLENVILLE ROAD, GLENVILLE, CONN.
SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, San Diego, Montreal.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.



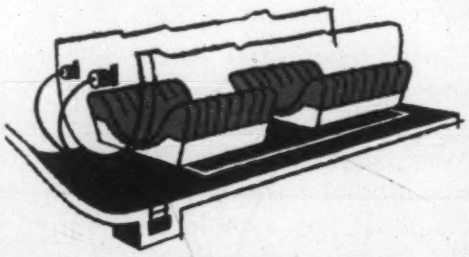
FELT for GASKETS (1)

There has to be a seal between the lid and body of electric power transformers, to exclude dirt and moisture, hold in the oil that insulates and cools. Felt is widely used for this purpose.



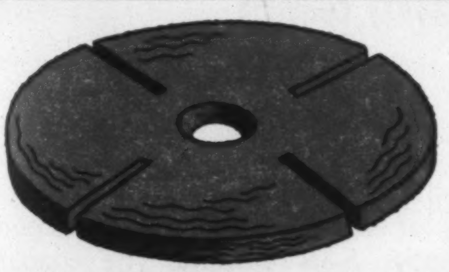
FELT absorbs VIBRATION (2)

To isolate spring-suspended gasoline tanks from the chassis of trucks and absorb road shocks and weaving strains, felt pads are used. These give enough to protect the tanks, but not enough to disturb gas lines.



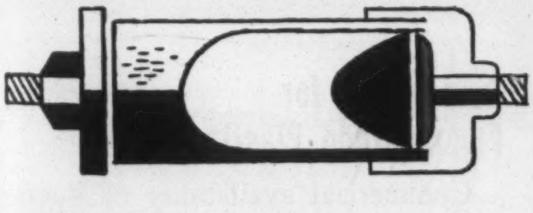
FELT for LUBRICATION (3)

Many locomotive journals are lubricated by felt, cut to fit the hub. Pumped oil is fed evenly, wastegrabbing eliminated. Length of life of the felt is estimated at 75,000 to 100,000 miles of perfect lubrication.



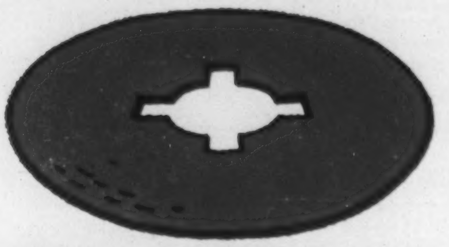
FELT for POLISHING (4)

The final polishing operation on steel cutlery changes the finish from dull to bright. About .002" of steel is removed by felt polishing discs, fed with fine pumice. The discs are slotted for flexibility.



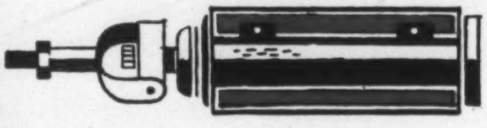
FELT in REFRIGERATION (5)

In refrigerators and air conditioners there is usually a cartridge filled with a dehydrating agent. Felt is used as a filter to prevent small particles of the drying crystals being carried into the refrigerant line.



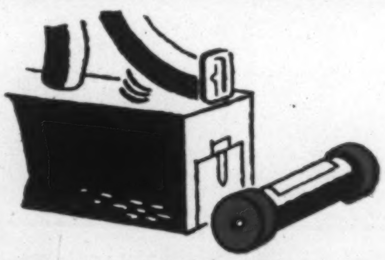
FELT CLUTCH FACING (6)

Industrial sewing machines have a clutch, which must take hold quickly, yet smoothly and firmly. These clutches operate properly when faced with felt discs cut to size and shape. This is a frictional application of felt.



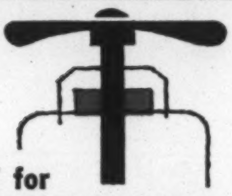
FELT for HONING (7)

The cylinders of internal combustion engines are finished by honing. The honing head carries abrasive stones alternated with strips of felt, the latter greatly improving the quality of the surface obtained.



FELT for SHOCKS (8)

Pneumatic carriers of both large and small sizes are in wide use. American supplies special felts for them. One type is used as a bumper head on the carrier to absorb shock on delivery; another is an air-pressure seal.



FELT for FIRE EXTINGUISHERS (9)

Hand-pumped fire extinguishers use felt washers for lubrication, for holding compression, as a bumper for the upstroke, and as a cushion for the nozzle. American also supplies flame-proofed felt for airplanes, theatres, etc.

AMERICAN FELT COMPANY
24 Glenville Road, Glenville, Conn.

1 2 3 4 5 6 7 8 9

Please send me further information about the application circled above.

NAME..

TITLE..

FIRM..

STREET..

CITY..ZONE.........STATE......................

For more information, turn to Reader Service Card, Circle No. 324

Tail section of a Douglas C-124, showing maze of heating and ventilating ducts

Aerotec pressure switches control heaters for thermal de-icing of flight surfaces as well as personnel heaters supplying the immense cabin and cockpit

Heart of this instrument is a diaphragm and two gaskets of COHRLASTIC 3010, the only material available that can withstand extreme heat and cold and thus activate the switch when the water manometer changes six millimeters. Despite this extreme sensitivity, these switches carry an electrical load of 10 amps at 28 vdc.

Just a dormant idea . . .
until along came COHRLASTIC 3010

Today this super-sensitive switch is used by every major aircraft manufacturer

This turtleback shell houses a delicate mechanism that must operate unfailingly under the hazards of elevated engine heats and sub-zero temperatures of stratosphere flying.

Mr. John V. Oliveau, vp Engineering, Aircraft Division, The Aerotec Corporation, writes: *"The high degree of dependability achieved by our switches in production over the past five years is, to an important extent, attributable to the remarkable properties of your Cohrlastic silicone rubber coated fabrics. We guarantee several types of this basic model to perform their function at all temperatures between −65 and +360 F., which is well within your operating limits of −100 and +500 F".*

SWATCHES AND LITERATURE ON REQUEST

COHRLASTIC
419 EAST ST. • NEW HAVEN, CONN.

PRODUCT OF THE
Connecticut
HARD RUBBER COMPANY

MANUFACTURERS OF SILICONE RUBBER COATED FABRICS REINFORCED WITH FIBERGLAS, NYLON, DACRON AND ORLON FOR SPECIFIC APPLICATIONS. MOLDED SHEETS, CUSTOM PARTS, EXTRUSIONS, PRESSURE-SENSITIVE TAPES, HIGH TEMPERATURE DE-ICING SYSTEMS, NON-LINEAR MOUNTS, CONDUCTIVE GASKETS.

For more information, turn to Reader Service Card, Circle No. 397

New Materials, Parts and Finishes

New Material Adds Flexibility to Epoxy Resins

A cashew bisphenol product, known as Cardolite 6463, has been developed by *Irvington Varnish & Insulator Div., Minnesota Mining and Mfg. Co.,* Irvington, N.J. When used as an intermediate in the preparation of epoxy resins the material is said to provide greater flexibility in the cured state.

According to the company, Cardolite 6463 requires about ½ the quantity of epichlorhydrin when used in the preparation of the epoxy resin. In addition to the raw material saving, the resins become readily soluble in the aromatic hydrocarbons.

The bisphenol is comprised of a phenol substituted in the meta position with a 15-carbon straight chain, with one or more other phenol molecules attached through their para positions at various points along the chain. It has a molecular weight of 410, nearly twice that of the usual bisphenol.

Stripper Speeds Removal of Epoxy Enamels

A new stripper designed to reremove epoxy and most other types of enamel has been marketed by *Enthone, Inc.,* Dept. MA, 442 Elm St., New Haven, Conn. Operating at room temperature, Enthone Stripper S-18 wrinkles the enamel, and the enamel and stripper are then removed by a water rinse. The stripper is non-flammable, mild in odor and a water seal is used to reduce evaporating losses. It removes enamels from brass and other base metals including aluminum and steel.

New Source for Fluorocarbon Plastics

Commercial availability of fluorocarbon plastics has been materially increased by the opening of a plant for the commercial production of Bakelite fluorothene resins by *Union Carbide and Carbon Corp.* Sale of the material will be handled by the

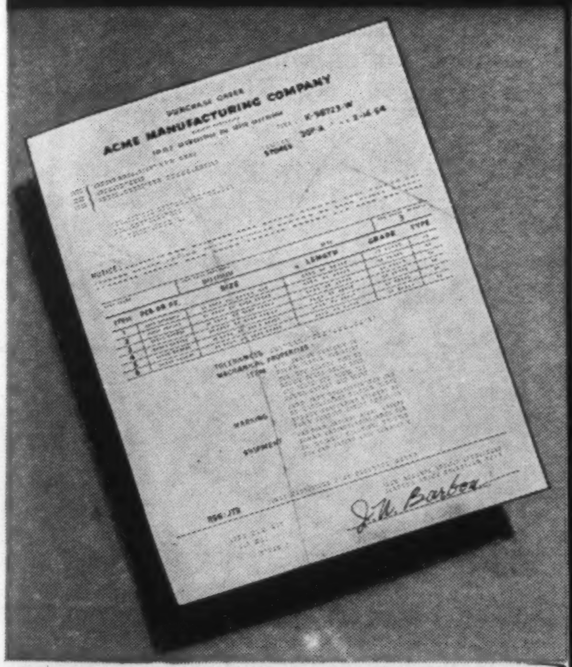
A AVAILABILITY

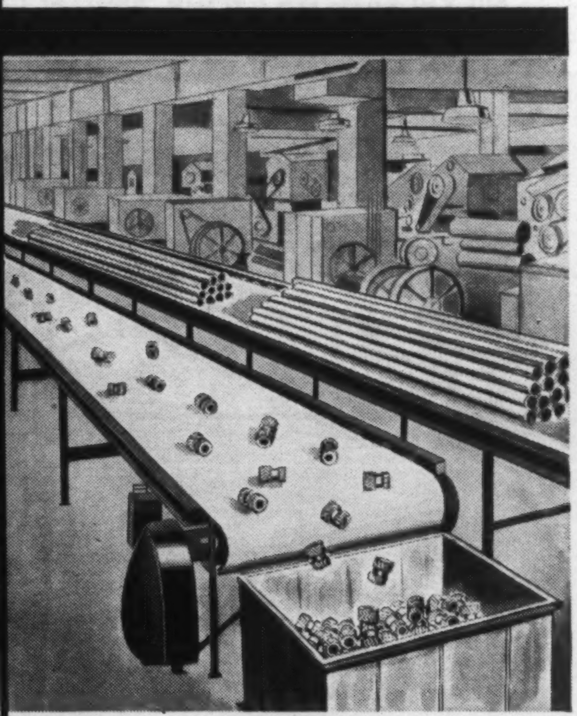
S SERVICE

Q QUALITY

you get all three with

B & W
CARBON STEEL
SEAMLESS
MECHANICAL TUBING





A AVAILABILITY
Buying convenience through a single source of hot-finished and cold-finished carbon steel tubing, produced in a wide range of grades and sizes.

S SERVICE
You can save through the dependable assistance of B&W Regional Representatives and qualified distributors, trained to help solve fabrication problems and to assist in tube selection.

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Mechanical properties, machinability, tolerances and surface finishes combined for ease of fabrication in your specific application.

remember* A S Q *is meant for you.

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THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
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Alliance, Ohio—Welded Carbon Steel Tubing

TA-4048 (CSM)

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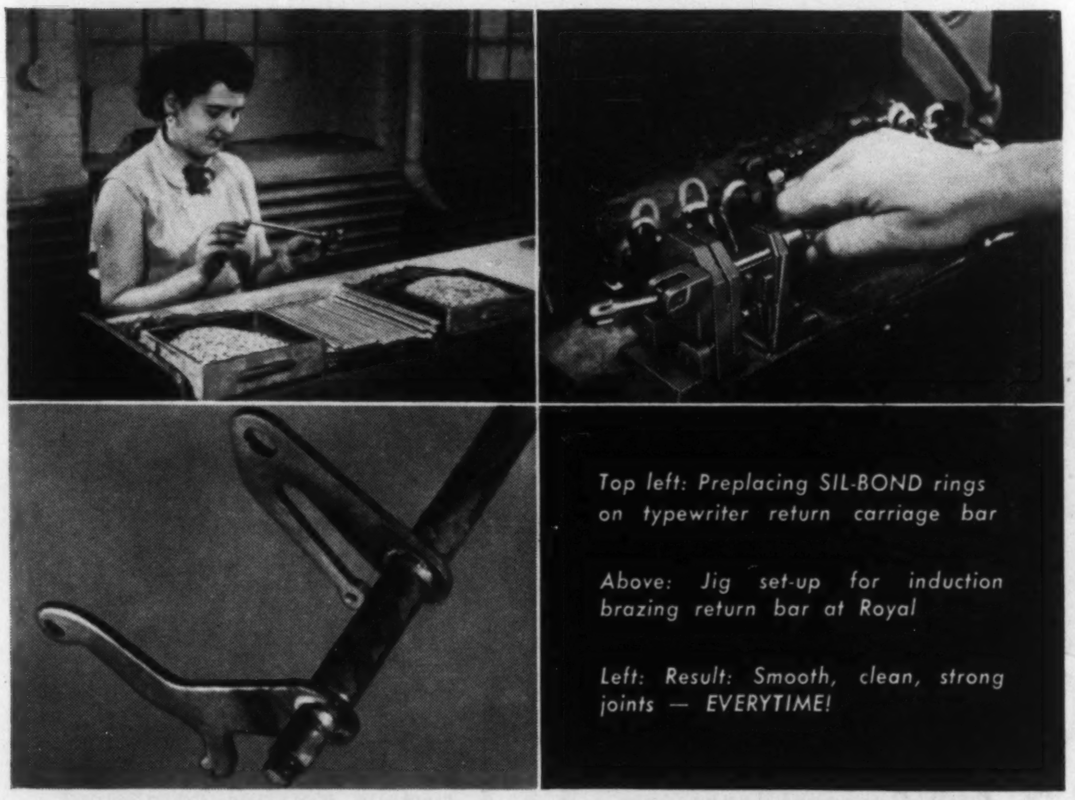
DEPENDABLE United WIRE SINCE 1889 BRAZING ALLOYS

Makes MASS PRODUCTION BRAZING *Easy* at ROYAL® Typewriter

Every day Royal Typewriter in Hartford, Connecticut proves the value of *SIL-BOND* low temperature brazing alloys in major mass production operations such as the sequence illustrated here.

Royal uses 15 sizes of *SIL-BOND* rings for strong, smooth joints, requiring no additional refinishing or grinding, which can be plated directly after brazing.

IF YOU MASS PRODUCTION BRAZE STEEL, COPPER, BRASS OR NICKEL ALLOYS, YOUR BEST ECONOMY BUY IS *SIL-BOND*.



Top left: Preplacing SIL-BOND rings on typewriter return carriage bar

Above: Jig set-up for induction brazing return bar at Royal

Left: Result: Smooth, clean, strong joints — EVERYTIME!

SIL-BOND COMES IN COILS, PREFORMED RINGS, STRIP OR STRAIGHT LENGTHS — IT'S *CHEMICALLY* BETTER — *PHYSICALLY* BETTER —

Send for SIL-BOND — B-80 Booklet NOW!

See New Color, Sound Movie "WHEN METALS ARE BRAZED" Write United Wire for showing date in your city!

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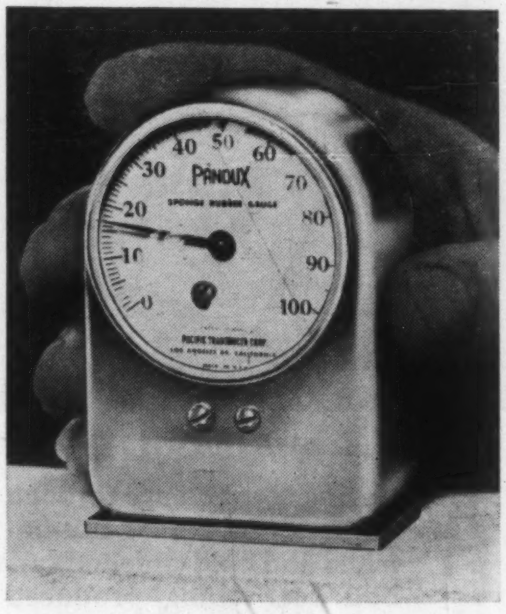
AND SUPPLY CORP.
BRAZING ALLOY DIVISION
PROVIDENCE 7, RHODE ISLAND
OFFICES IN PRINCIPAL CITIES

For more information, turn to Reader Service Card, Circle No. 319

Bakelite Co., 30 E. 42nd St., New York.

The fluorothene resin is a polymer of chlorotrifluoroethylene, as is Kel-F produced by M. W. Kellogg Co., and their properties are similar. It has high volume resistivity at temperatures in the 200 to 390 F range, a low dielectric constant, high dielectric strength, and good moisture resistance. The softening temperature is high; it has good resistance to burning, chemicals and weathering and high tensile and compressive strengths. It is useful over a temperature range of —320 to 390 F.

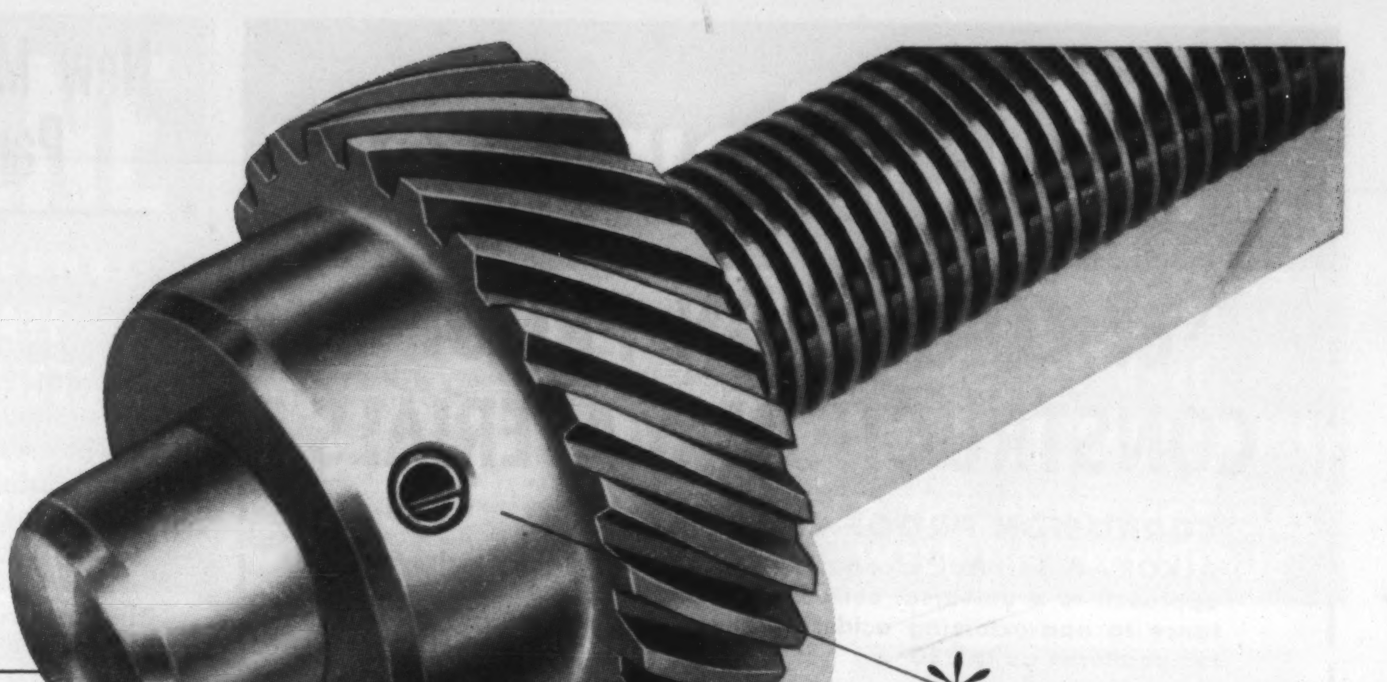
A great deal of initial production is being absorbed by the military, according to the company. The resins are being used as wire insulation, ammunition components, and as barriers to corrosive chemicals.

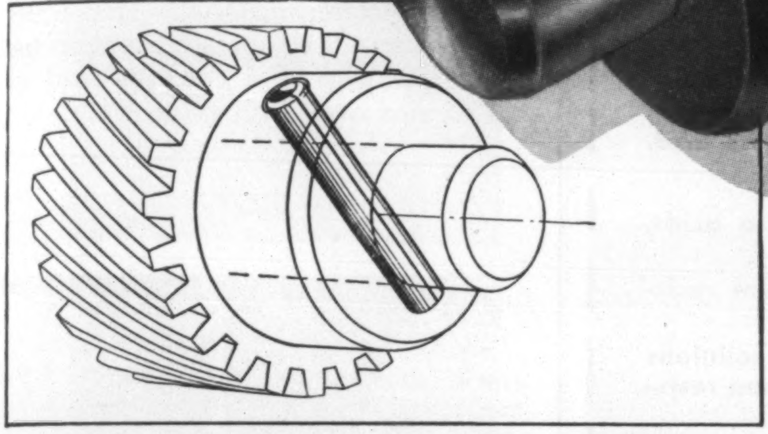


Softness Tester for Foam Rubber

A hand tester for the measurement of hardness or resiliency of foam and sponge rubbers, as well as other soft elastomers, has been developed by the *Pacific Transducer Corp.*, 11921 W. Pico Blvd., Los Angeles 64.

Measurement is made by pressing the Model 302S Pandux Foam Rubber Tester against the material to be measured so that the base is flush with the material surface. The indentor then gives a direct reading on the scale of the dial. Accurate read-

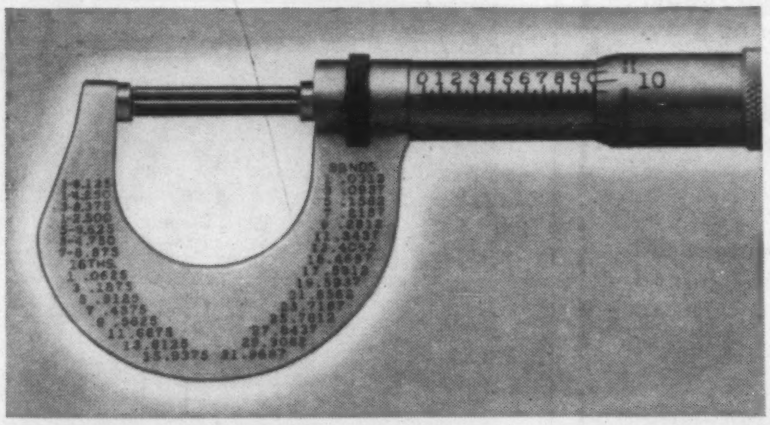




* *consistent quality*

is as important in the pin as in the gear

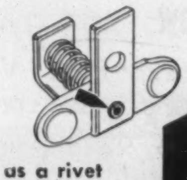
To function effectively, a spring pin must drive easily into holes drilled to normal production tolerances, compressing as driven. To drive easily, hold firmly and fit flush, the pin –*every* pin–must meet the strict requirements of specifications such as those prepared by the SAE and the Military Services.



Since failure of a pin can be as costly as a failure of any other precision part, it is important to check the pins *you* buy for uniformity . . . uniformity of diameter and length, shear strength, hardness, insertion and removal forces, and recovery of diameter.

Rollpin has been tested many times – by many manufacturers – with a consistently high performance record. It has been widely recognized as the "quality" fastener of its type. In this case, quality can be – and should be – measured. We strongly urge that you test for quality when buying spring pins.

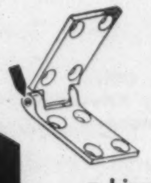
ELASTIC STOP NUT CORPORATION OF AMERICA



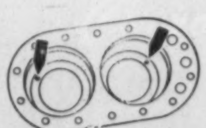
as a rivet

ROLLPIN

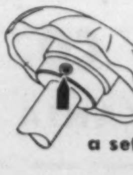
TRADEMARK



a hinge pin



a dowel



a set screw

Dept. R28-661, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send the following free fastening information:

☐ Rollpin samples
☐ Rollpin bulletin
☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name__________________ Title________
Firm____________________________
Street__________________________
City______________ Zone____ State______

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The ATLAS DIRECTORY

of CORROSION PROOF CONSTRUCTION MATERIALS*

☐ **CORROSION PROOF CEMENTS**

☐ ALKOR—A furfural alcohol resin cement which is the nearest approach to a universal corrosion resistant cement. Complete resistance to non-oxidizing acids, alkalies, salts and most solvents at temperatures up to 380° F.

☐ VITROBOND—An economical hot pour sulfur cement having excellent resistance to non-oxidizing acids and moderate concentrations of oxidizing acids such as nitric and chromic.

☐ CARBO-KOREZ—Phenolic base cement resistant to non-oxidizing acids, salts and most organic solvents. Excellent for sulfuric acid.

☐ **CORROSION PROOF LININGS**

☐ ATLASTAVON—Polyvinyl chloride sheet lining resistant to acids, alkalies and some solvents.

☐ SARAN SHEET—General purpose tank lining with excellent resistant properties.

☐ NEOPRENE SHEET—Synthetic rubber lining resistant to water solutions of non-oxidizing acids, salts and alkalies, exhibiting excellent resistance to abrasions.

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☐ ZEROK SERIES—A complete series including vinyl chlorinated rubber and styrene butadien copolymer based coatings. Black, white and gray.

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☐ ATLASTISEAL—A hot melt three layer system lining used behind brick for protecting concrete tanks against corrosion of water solutions of non-oxidizing acids and salts.

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☐ ATLAS ACID-ALKALI-SOLVENT-GREASE PROOF FLOORS—composed of an impervious flexible membrane and acid proof brick joined with corrosion proof cement. These floors have been solving Industry's floor problems for over a quarter century.

☐ **FURNANE FLOORS**

☐ FOOD INDUSTRY FLOORS—A dual cement floor construction especially designed for use in food processing plants and biological laboratories.

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A complete line of rigid fabrications built to specifications for exhaust systems, duct, process equipment, tanks and liners made from the plastic best suited for the requirement of the structure. Pipe of standard size available.

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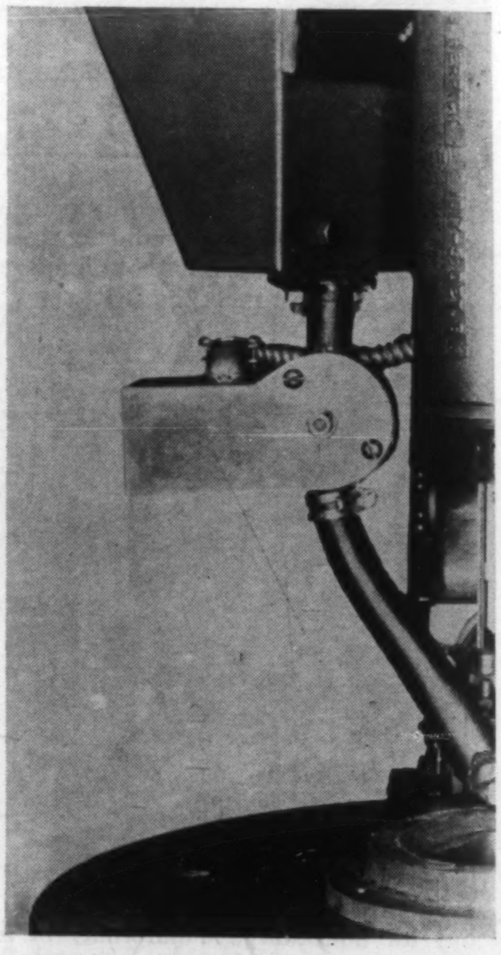
*Trade Names Reg. U. S. Pat. Office. Alkor, Vitrobond, Carbo-Korez, Atlastavon, Neobon, Neelium, Zerok, Furnane.

ATLAS
MINERAL
PRODUCTS CO.
MERTZTOWN, PENNSYLVANIA

For more information, turn to Reader Service Card, Circle No. 414

ings can be gained on specimens down to ¾ in. thick. Thinner specimens should be stacked for testing.

The scale of the instrument is based on load displacement. A given load is applied over a given area. The displacement of the load is indicative of the resistive quality of the material. Greater displacement under a constant force will result from a softer material. The values on the Pandux scale are based on the displacement of a constant load of 250 gms over an area of 1 cm.



Automatic Valve Aids Control of Flux Flow

A new Automatic Flux Valve which is said to give positive control of the flow of flux on automatic, submerged arc welding operations has been developed by the *C. B. Herrick Mfg. Corp.*, 1935 Euclid Ave., Cleveland 15.

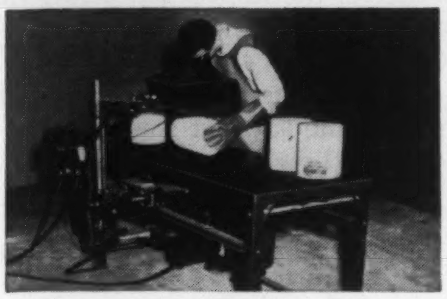
The valve has been designed to operate with all Type LAF-2 Automatic Welding Heads. When the operator turns the "Inch Down"

AGILENE

(POLYETHYLENE)

for ULTIMATE CORROSION RESISTANCE

BY THE AGILE HOT GAS WELDING, FLAME SPRAYING, and FLOC-COATING METHODS



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Agile's strict quality control for every fabricated and semi-finished component assures you of material which is homogeneous, non-degraded, and free from voids.

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Largest sheets available! They range in size from 1/16" to 1" in thickness and the over all size is 48" x 72". Agilene sheets are molded from virgin Polyethylene resin, natural or black pigmented, and are free from air inclusions.

AGILENE ROD

Largest sizes available! Standard diameter ranges from 1/2" to 3" and standard lengths from 12 to 60 inches. Molded from virgin Polyethylene resin, natural or black pigmented.

AGILENE BLOCK

Largest sizes available! Standard dimensions range from 12" x 12" x 1" to 12" x 12" x 4" molded from virgin Polyethylene resin, natural or black pigmented. Larger sizes also available.

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Largest sizes available! Up to 1,000 pounds.

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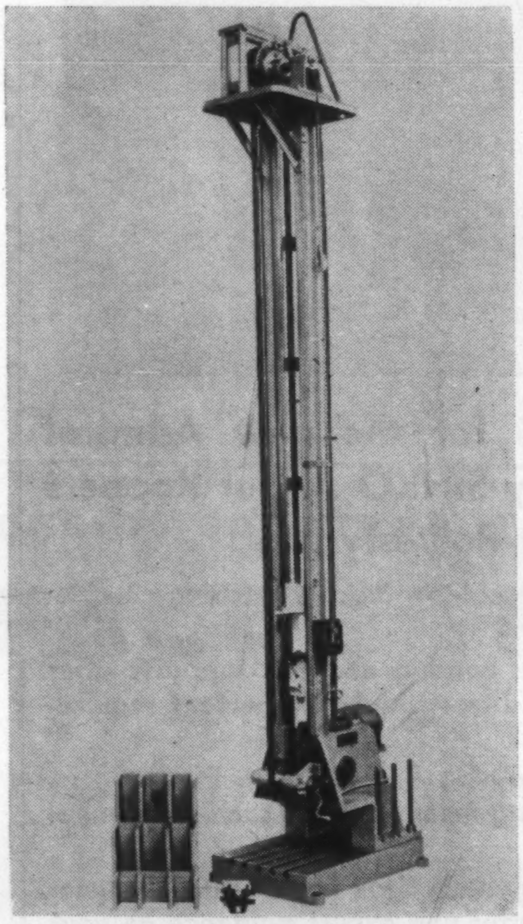
For more information, Circle No. 441

New Materials, Parts and Finishes

switch to weld position, the flux automatically begins to flow after the electrode contacts the work. When the switch is reversed, the flux flow stops.

Use of the switch is said to eliminate waste of flux and prevent the possibility of the operator neglecting to start the flux flow. The Herrick Flux Valve is designed to be attached directly under the flux hopper, and will not jam in either an open or closed position.



Impact Tester Checks Quality of Materials

A new automatic progressive and repeat impact testing machine for determining the breaking point of gear teeth and studying the dynamic properties of parts subject to shock has been developed by the *Tinius Olsen Testing Machine Co.,* 1054 Easton Rd., Willow Grove, Pa.

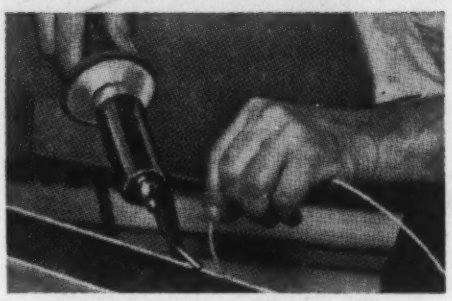
In operation, a hammer of known weight is automatically raised and dropped on the test specimen from progressively higher points until the specimen breaks. The quality of the material can be determined from the

AGILIDE

(NON-PLASTICIZED POLYVINYL CHLORIDE)

for ULTIMATE CORROSION RESISTANCE

BY THE AGILE HOT GAS WELDING TECHNIQUE



For Hot Gas Thermo-Plastic Welding (electrically operated 110 volt gun) complete with 15 feet each inert gas or air hose, rubber covered flexible electric cord. Ask for Bulletin "Hot Gas Welding."

AGILIDE SHEET

Largest sizes available! Thicknesses range from 1/16" to 1" and the overall size is 48" x 72" and 108". These sheets may be cut to size.

AGILIDE ROD

Largest sizes available! Diameters from 1/4" to 1". Standard lengths are 10' 0". May be cut to any length desired.

AGILIDE BLOCK

Largest sizes available! Dimensions from 12" x 12" x 1" to 12" x 12" x 4".

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ACKNOWLEDGED Pioneers IN THE WELDING OF STRUCTURAL PLASTICS

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Perfection in Plastics

HOUSING and LEG SUPPORTS for the new Admiral Moisture Conditioner molded by SINKO . . . of Koppers MC-309 High Impact Polyestyrene

Exceedingly attractive . . . grained to resemble wood . . . a fitting complement to the most richly furnished living room.

And in addition to good looks, both the housing and leg supports offer maximum resistance to impact, moisture, and heat; highly important requirements in an appliance such as this.

You'll find the SINKO name synonymous with Perfection in Plastics . . . that is why we are today serving many leading manufacturers such as Admiral on their needs in molded plastics.

We mold all Thermoplastics including Nylon, in sizes from 4 to 60 ounce; and have the experience and know-how to offer you expert guidance on your particular requirements.

Contact us just as soon as you have a molding problem . . . we welcome your inquiries!

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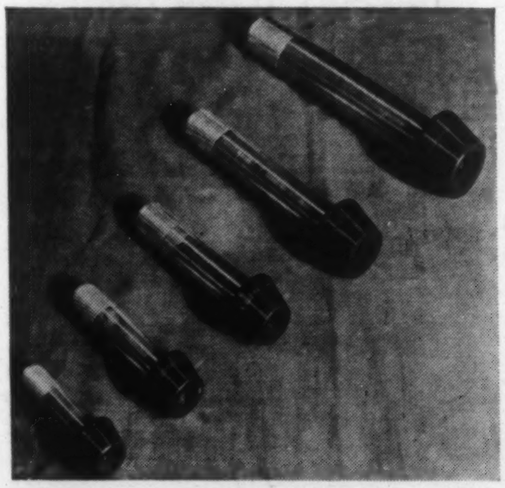
height of the fall and the number of blows delivered at fracture.

After each stroke the hammer is picked up by a motor driven chain and raised to the next dropping point. Height of the fall is increased by 1 in. for each succeeding stroke. The machine can also be set to deliver the impact repeatedly from any desired height between 6 in. and 10 ft.

The specimen holder is adjustable to accommodate test specimens up to 24 in. in height.



High Strength Steel Bolts Aid Airframe Assembly

Precision steel bolts with a rated tensile strength of 200,000 to 225,000 psi are being produced by *Standard Pressed Steel Co.*, Jenkintown, Pa. According to the company, they were designed to meet the need for resistance to increasing shock and vibrational stresses encountered by sonic and supersonic aircraft.

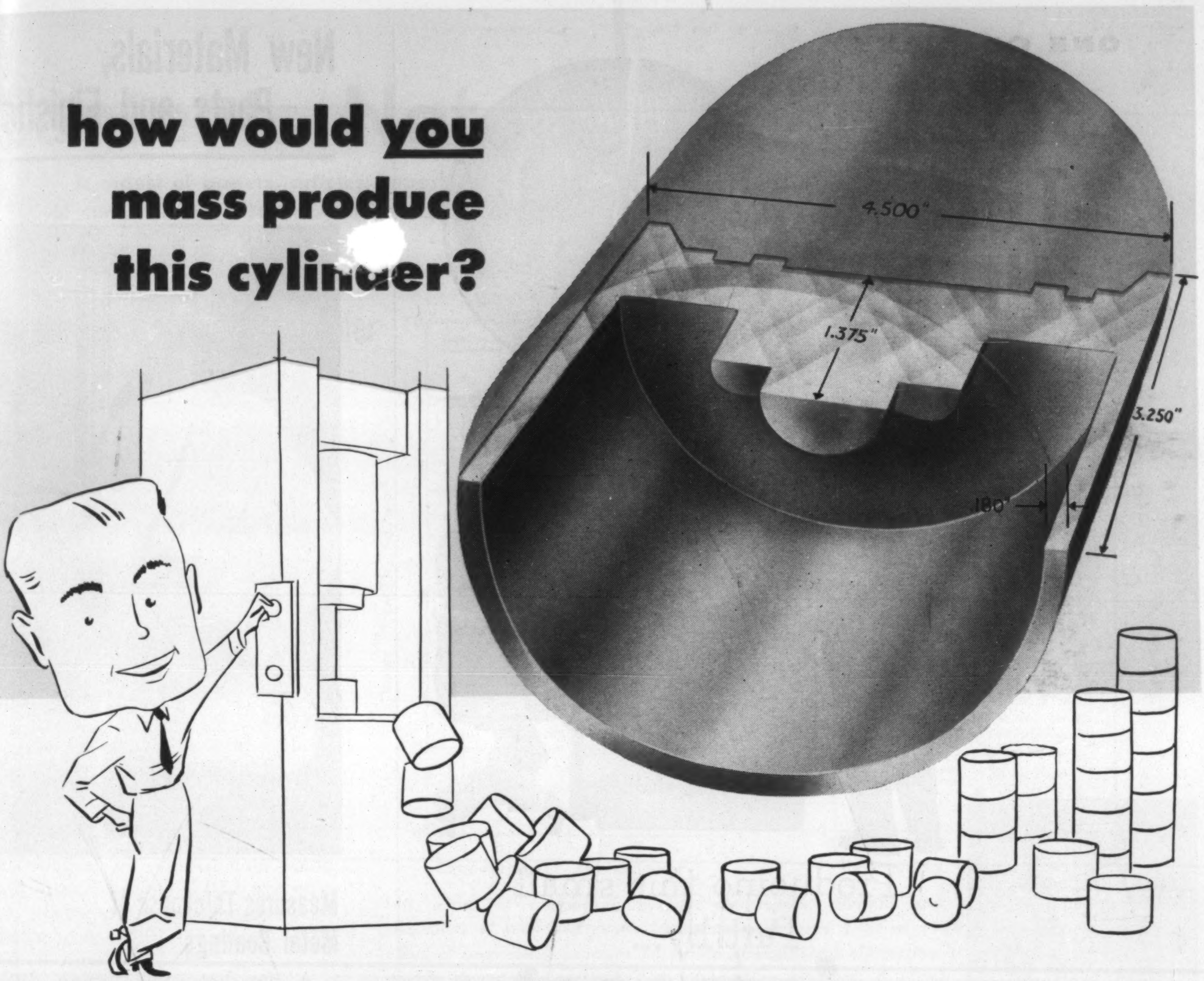
The bolts are forged from 8740, 4340 and 4140 high alloy steels. Bolts up to 1¼ in. are cold forged while larger sizes are hot upset forged. The finished bolt is free of decarburization and cadmium plated.

The high tensile strength of the material was made possible, according to SPS, by the designing of tools and equipment which could cold roll finished threads in steels with hardnesses in the range of Rc 40-43 which are encountered with tensile strengths of this magnitude.

(Continued on page 172)

For more information, Circle No. 491 ➤

how would you mass produce this cylinder?



For efficiency and economy specify...

H|D IMPACT FORGING

FROM

HIGH STRENGTH ALUMINUM ALLOYS

Strength requirements of this cylinder were satisfied by using a heat treatable aluminum alloy (minimum yield 55,000 P.S.I.). By the Hunter Douglas cold Impact Forging technique, this high strength aluminum alloy was forged in a single operation to the desired shape...mass production at its finest...with close dimensional tolerances, forged grain flow and walls of zero draft.

The raised stud in the center of the piston offered an added design problem that, by any other process, would present a tremendous time consuming contour milling operation, in addition to high metal waste. The economic advantages of producing this part with minimum metal waste and in a single forging operation are immediately evident. When you are designing a part with the following characteristics:

Walls of zero draft...High physical properties ...Tubular shapes with or without a closed end ...Close dimensional tolerances...Mass production requirements up to a million a month...

IMPROVE YOUR COMPETITIVE POSITION...
SPECIFY HUNTER DOUGLAS

We invite you to submit blue prints or parts for our engineering department's prompt analysis.

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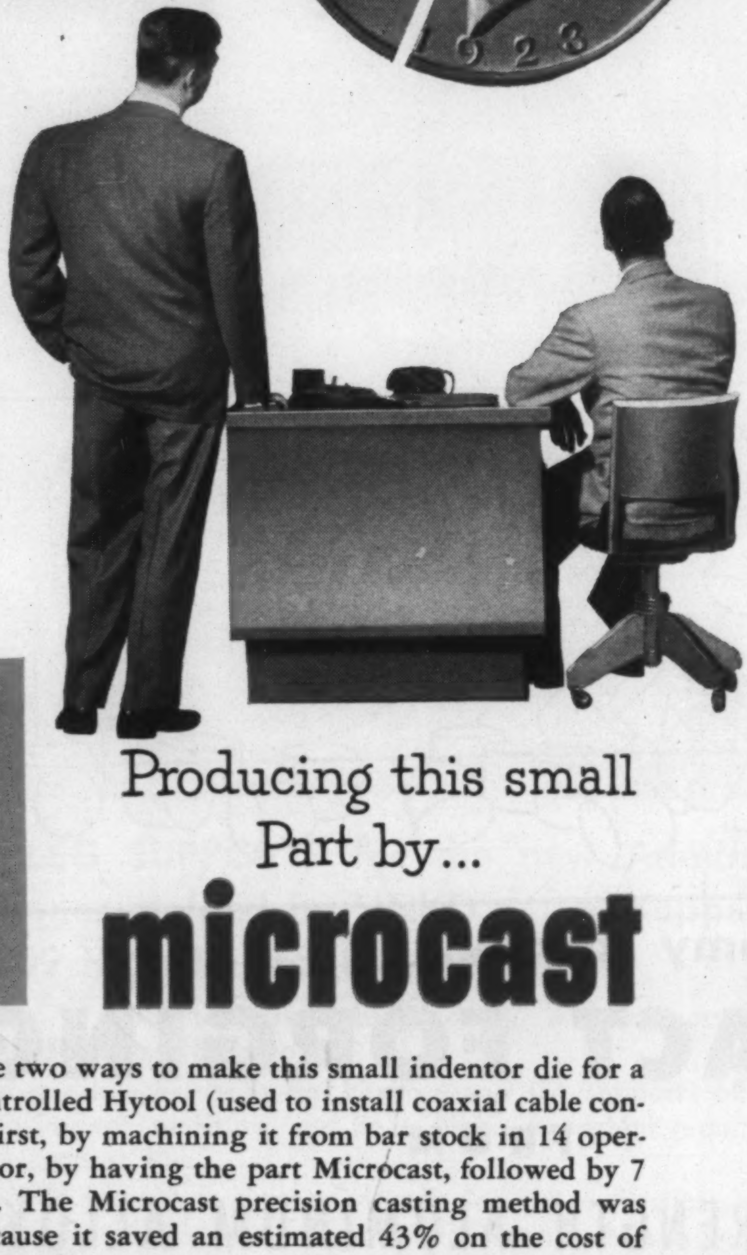

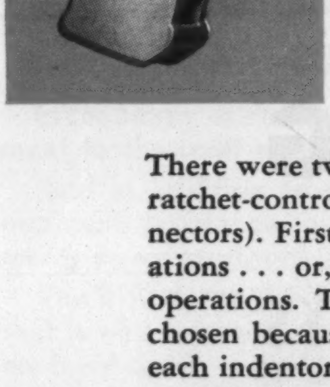

Producing this small Part by...

microcast

There were two ways to make this small indentor die for a ratchet-controlled Hytool (used to install coaxial cable connectors). First, by machining it from bar stock in 14 operations . . . or, by having the part Microcast, followed by 7 operations. The Microcast precision casting method was chosen because it saved an estimated 43% on the cost of each indentor die.

If the expense of machining intricate parts and components is throwing your production budget out of line, let us show you how the Microcast process can help you. Microcast can not only eliminate machining operations but it also allows you to engineer for better design through the use of high-heat alloys.

Write for free booklet. Full color talking film of the Microcast process available without charge.

MICROCAST PRECISION CASTINGS PROCESS ®

microcast

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The Original Process for Mass Producing Precision Investment Castings.

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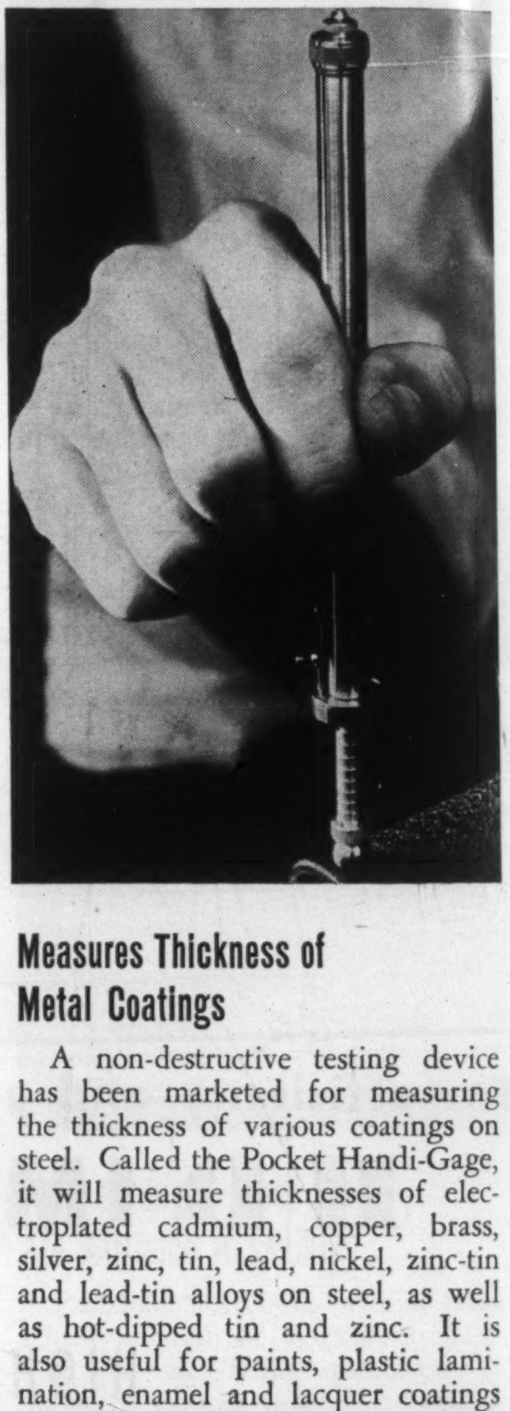
New Materials, Parts and Finishes



Measures Thickness of Metal Coatings

A non-destructive testing device has been marketed for measuring the thickness of various coatings on steel. Called the Pocket Handi-Gage, it will measure thicknesses of electroplated cadmium, copper, brass, silver, zinc, tin, lead, nickel, zinc-tin and lead-tin alloys on steel, as well as hot-dipped tin and zinc. It is also useful for paints, plastic lamination, enamel and lacquer coatings on steel. It will measure thicknesses from 0.0001 to 0.015 in.

Developed by *Platers Research Corp.*, 59 E. 4th St., New York 3, the instrument is magnetic, and similar in size and shape to an automobile tire gage. When the magnetic end of the Handi-Gage is applied vertically to the surface to be tested and slowly pulled away, a calibrated inner stem appears. The distance the stem travels before the magnet releases itself from the surface is a measure of the thickness of the coating.

The instrument is designed for use on the production line, laboratory, or any place where thicknesses are to be controlled. It is supplied with extra magnets for various thickness ranges.

Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- German Powder Metallurgy
- Facts About Cold Extrusion
- Primary Effects of Fretting
- Cold Welding Titanium

German Electrolytic Iron Powder

Because of its purity and other good properties, electrolytic iron powder has recently found increased use for sintered parts that must have high dimensional stability and strength. Also, electrolytic iron powder has proven to be highly suitable for the production of alloyed sintered steel since the alloy content can be controlled more precisely and the influence of harmful impurities is avoided.

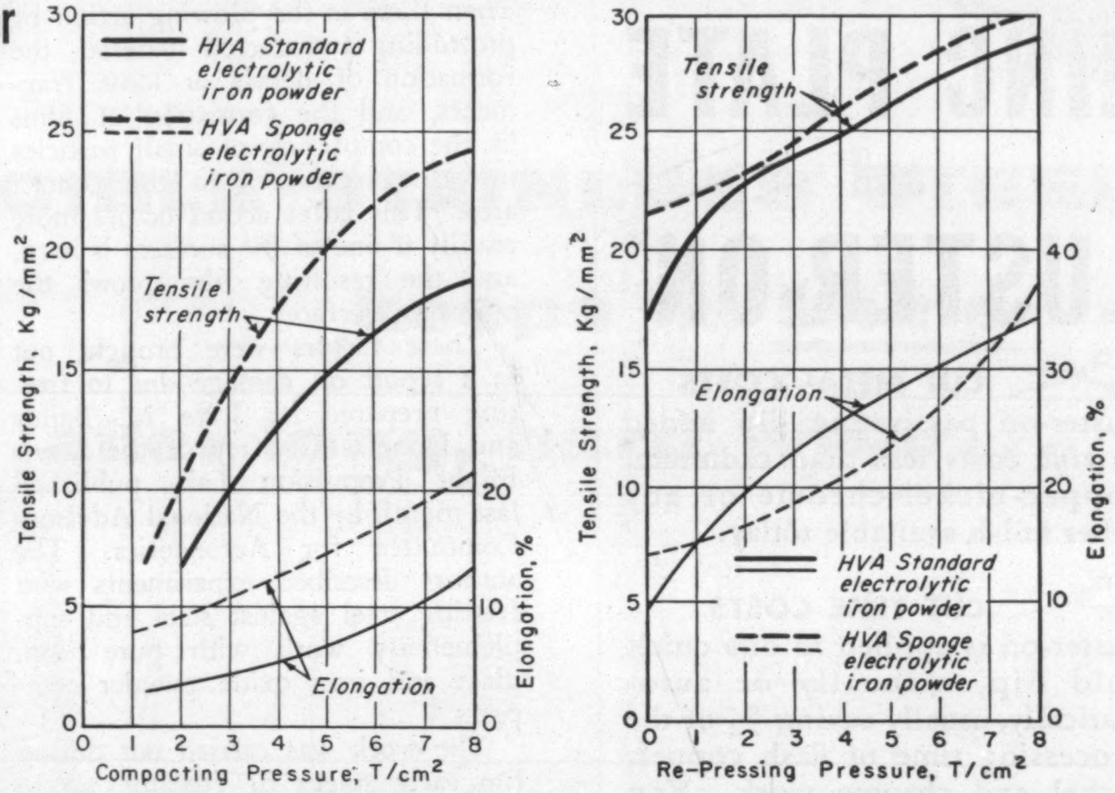
These factors are pointed out by Ivan Ljungberg in a report published in the Feb. 25 issue of *Stahl und Eisen* (German) this year, on the HVA electrolytic iron powder produced by Husqvarna Vapenfabriks Aktiebolag. This powder contains the following maximum allowable percentages of constituents other than iron: carbon—0.05, oxygen—0.5, silicon—0.02, manganese—0.06, phosphorous—0.01, sulfur—0.01, and chlorine—0.1.

The low silicon content is one of the reasons for the low tool wear encountered in compacting this powder. Although the properties of the powder can be varied within wide limits, HVA has standardized on two types. HVA standard electrolytic iron powder was developed for use with double compacting. It gives high density, tensile strength and elongation values even with low compacting pressures.

HVA sponge electrolytic iron powder is used for the production of porous sintered parts with high elongation values. Because of the shape and fine size of the particles it gives lower densities than can be obtained with the standard powder but higher tensile strengths and elongations, particularly with a single compacting.

The accompanying table shows the typical properties of the HVA electrolytic powders, and the curves point out the tensile strength and elongation resulting from both single and double compacting of the two powders.

(More Contents Noted on page 174)



***Left:* effect of compacting pressure on tensile strength and elongation of sintered specimens of HVA electrolytic iron powder sintered 1 hr at 1920 F in hydrogen. *Right:* effect of re-pressing pressure on tensile strength and elongation of powders processed by double compacting method. First compacting pressure, 6 t/cm²; first sintering 1 hr at 1920 F in hydrogen; second sintering 2-½ hr at 2280 F in hydrogen.**

Properties of HVA Electrolytic Iron Powders

Property	HVA Standard Electrolytic Iron Powder	HVA Sponge Electrolytic Iron Powder
Particle size distribution sieve mesh width, mm		
over 0.20, %	1-5	...
0.20–0.10, %	10-20	1-5
0.15–0.10, %	20-30	10-20
0.10–0.06, %	20-30	25-35
under 0.06, %	25-35	30-50
Apparent density, Gr per cu cm	3.2-3.3	2.6-2.8
Rate of flow, Sec per 50 gm	25-27	30-32
Heating loss in hydrogen, %	under 0.5	0.5
Green strength, %[1]	under 1.5	0.9
Compactibility, Gm per cu cm[2]	6.7-6.8	6.4-6.6

Note: [1] *Determined by the drum or rattler test.*
[2] *Compacting pressure 4 ton per sq cm.*

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ZINC PLATE and LUSTER-ON®

CUT METAL COSTS
Luster-on passivating dip added to *zinc* costs less than cadmium, copper-nickel-chrome or any other finish available today.

CUT TIME COSTS
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Fretting in Materials—Causes and Effects

There are several causes of damage during the early stages of fretting. First is the strong adhesion between the surfaces, as indicated by the initial coefficient of friction. Then there is the plowing action by protruding transferred material, the formation of debris or loose fragments, and the formation of films by the compacting of small particles into the clearances in the contact area. This latter action occurs more readily if one of the surfaces is hard, and the resulting film plows the opposing surface.

These factors were brought out in a report on damage due to fretting prepared by John M. Bailey and Douglas Godfrey of the Lewis Flight Propulsion Lab, published last month by the National Advisory Committee for Aeronautics. The authors described experiments with fretting steel against steel and supplementary work with pure iron, glass and iron oxide powder compacts.

The work was carried out during the early stages of fretting, up to 400 cycles, at a frequency of 5 cpm, an amplitude of 0.006 in., a load of 150 gm, and in air with a relative humidity of less than 10%.

The fretting of steel against steel started with coefficients of friction between 0.60 and 0.70, followed by formation of the films, some plowing, production of loose Fe_2O_3 debris, and a subsequent reduction in the coefficient of friction to between 0.53 and 0.61. A rather stable coefficient of friction was reached after about 20 cycles, giving values which rose slowly to between 0.58 and 0.65 at 300 cycles.

With the glass specimens, films were formed by the compacting of fragments which could plow an opposing metal surface. Coefficient of friction values obtained when glass was one of the specimens were generally higher than those obtained with metal to certain metal combinations.

Fretting of pure iron against pure iron produced mass welding and subsequently metallic fragments and severe plowing. The initial coefficient of friction was 0.82. This reduced to 0.60 in 25 cycles, and after 100 cycles reached an essentially stable value of 0.64 as metallic debris accumulated.

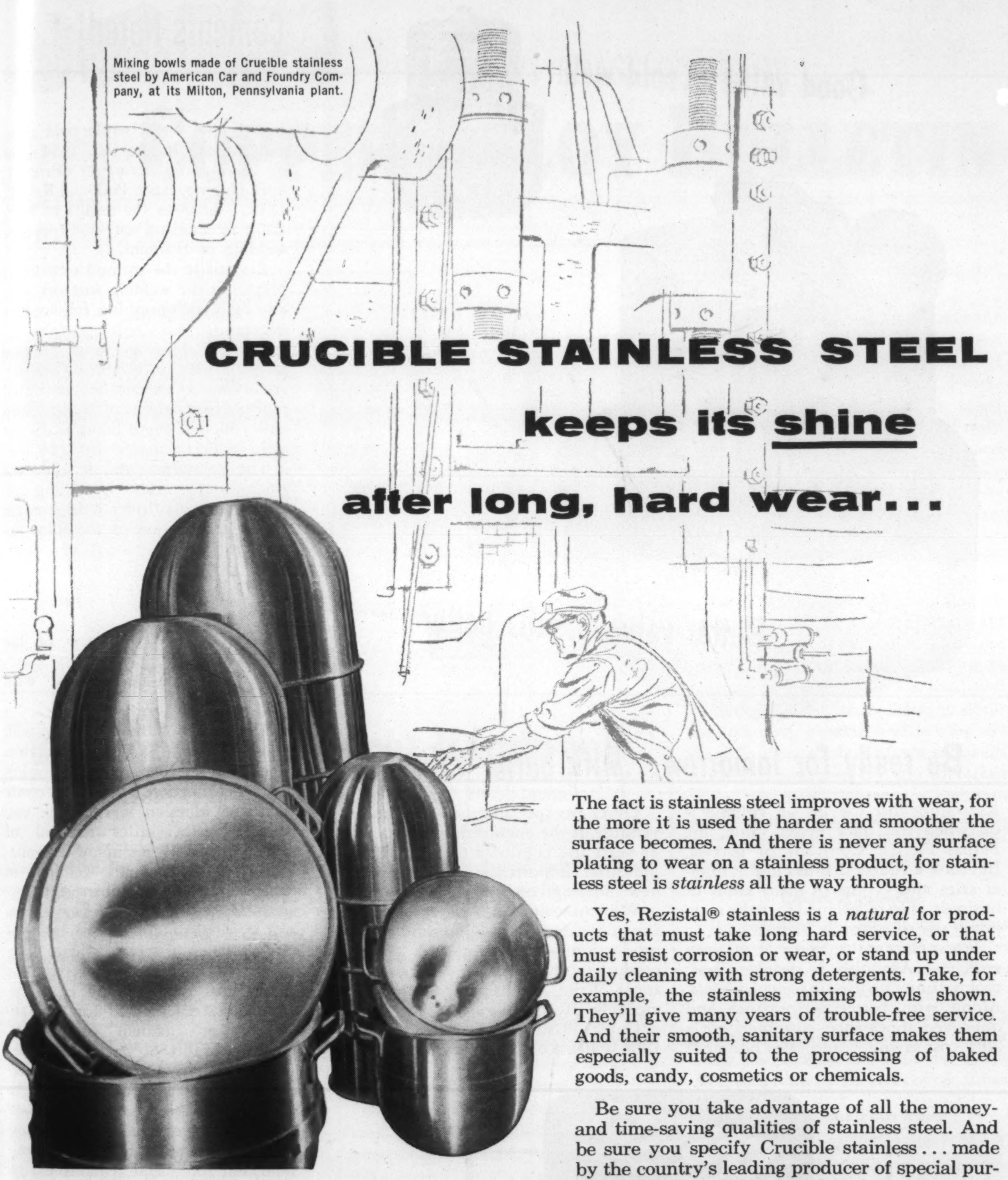
Iron oxide compacts (both Fe_2O_3 and Fe_3O_4) fretted to form Fe_2O_3 debris the same as that found in fretting of steel. The coefficient of friction for Fe_2O_3 compacts fretted against Fe_2O_3 compacts was initially 0.60 and within 100 cycles reduced to an essentially stable value of about 0.51. The coefficient of friction of Fe_3O_4 compacts fretted against Fe_3O_4 compacts began at 0.30, then slowly increased to about 0.50 after 600 cycles.

Titanium Can Be Cold Welded

In the article on page 107 of this issue, the problems encountered in welding and brazing titanium and its alloys are pointed out. Since most of the difficulties arise from the use of heat in joining, the question of

Test Results on Cold Welding Titanium

	Minimum Deformation for Adhesion, %	Minimum Deformation for High Strength, %
Titanium to Titanium (100 V.P.N.)	50	78
Titanium to Titanium (130 V.P.N.)	50	85
Copper to Titanium (130 V.P.N.)	55	85
Aluminum to Titanium (130 V.P.N.)	50	71
Iron to Titanium (130 V.P.N.)	60	>85



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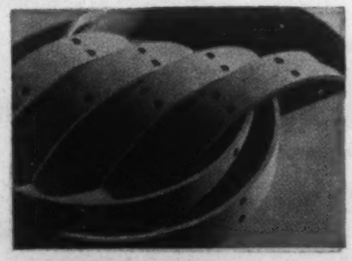

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joining the metal while cold naturally arises. In the Jan. 1954 issue of *Sheet Metal Industries* (British), J. E. Hughes, B.Sc., Ph.D., A.R.S.M., D.I.C., discusses the results of work done in England on cold pressure welding of titanium.

Essentially the method consists of preparing the welding surfaces, usually by scratch-brushing followed by degreasing, placing the surfaces together and applying enough pressure to bring them into intimate contact. According to the author, interstitial films such as oxides are broken down and a high strength bond across the weld plane is effected.

The parameter used to state the amount of surface spreading required for a particular weld strength is the deformation of the joint defined as:

$$\frac{T_1 - T_2}{T_1} \times 100\% \text{ where}$$

T_1 = total initial thickness of the sheets.

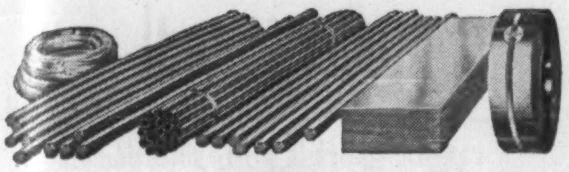
T_2 = total final thickness of weld area.

The results of the tests made with titanium (iodide) are shown in table. These figures refer to 1) the minimum deformation required to create sufficient adhesion to hold the two sheets together after removal of pressure, and 2) minimum deformation for high-strength welding, in which fracture on subsequent mechanical testing occurs away from the weld plane and in the body of the sheets.

The author concludes from the results that cold welding is a possible industrial method for the fabrication of titanium components. The weldability of the metal is dependant on its purity, and the deformations required for high-strength joints are of the same order as those required for copper. Higher pressures are required than for aluminum and less metal remains in the joint, but this is partly offset by the greater strength of the joints.

What About Cold Extrusions?

Cold extruding can be a highly economical and advantageous method of metal forming. The advantages in the process can be briefly summarized as follows: less expensive raw materials, since higher physicals



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BRIDGEPORT
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In addition, the "Technical Handbook" contains information on the importance of the microstructure of rolled and annealed brasses, graphically illustrated by micrographs and curves.

Mill Product Shapes

The following three sections are devoted to mill products—strip and sheet, rod and wire, and tubing. They are further broken down into groups such as Brass and Copper Strip for Drawing, Spinning and Stamping; Rods for Screw Machine Operation; Wire and Rod for Cold Heading; Rods for Hot Forging; Tubing for Fabrication; and many others.

Each classification lists not only the alloys and their applications, but gives a table of Composition, Mechanical Properties, Physical Constants, Fabrication Properties, as well as the latest specification numbers. By referring to these tables, the purchasing agent and the design engineer can see at a glance the alloys available and their comparative properties. This simplifies alloy selection, saves time and effort.

Hints on Metalworking

The handbook contains a brief but authoritative outline of procedures for working copper-base alloys. There are many diagrams and tables relating to machining, the tools to be used and recommended coolants. Data on Milling, reaming, chasing and sawing are given in concise tabular form with suggested procedures for the different alloys discussed. There are also full sections on drawing and drawing lubricants, annealing, cold heading, soldering, cleaning and dip coloring.

Useful Appendix

To complete the Handbook, almost thirty pages of informative tables are included as an Appendix. These tables cover equivalent weights, temperature conversions, metal melting points, length measurement conversions, and weights of flat products, circles, rod, round wire and copper tubes.

How to Get Your Copy

The Bridgeport "Technical Handbook" is a reliable guide to many problems and situations met by purchasing agents, design engineers and production superintendents in every-day work with copper-base alloys. Your copy will be quickly mailed upon request on company letterhead. And if you are confronted with metal problems not completely answered in the Handbook, do not hesitate to contact our nearest branch office for assistance as well as for your metal requirements. (1593)

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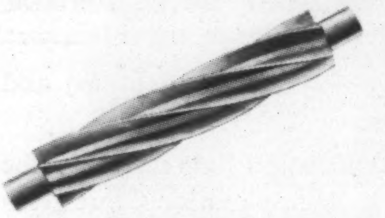
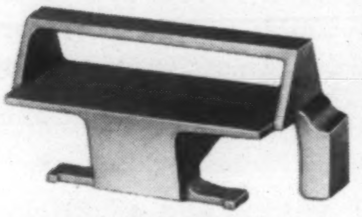
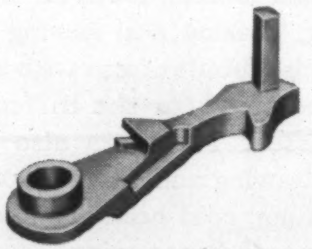
FACTS ABOUT ATLANTALLOY PRECISION PLASTER MOLD CASTINGS


One-piece cast ice cutter for York Corporation's Automatic Ice Maker replaced fabrication of several stainless steel parts.


Cast brush holder for General Electric aircraft generators lowered costs, provided closer tolerances and increased strength.


Lever casting of *Atlantalloy* #31 manganese bronze with tensile strength of 100,000 psi for Sargent & Greenleaf's manipulation-proof lock.

Rugged skirt door operating mechanism cast for Pennsylvania Railroad cars manufactured by the Budd Company.

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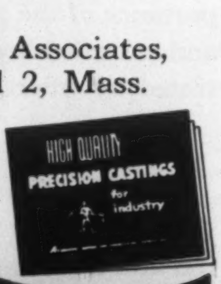

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Contents Noted

continued

can be gained with cheaper metals, reduction in scrap waste, improved physicals in the final part, and less finishing machining.

In a paper presented at the SAE National Passenger Car Body & Materials Meeting in March of this year, J. F. Leland and J. W. Helms of the Parker Rust Proof Co. discuss the status of cold extruding, the materials and lubricants used, and the results obtainable.

The authors point out that a great deal of the advances in the process have been attributable to the development of phosphate coatings which become integrated with the surface of the metal and thereby act as a vehicle for the lubricant. The lubricant system produced must provide an uninterrupted film and separating or anti-flux layer between the tools and workpiece at the high temperatures (up to about 450 F) and unit pressures (up to about 300,000 psi) developed during deformation of the metal. Complete removal of scale, surface oxides, grease and soil is essential to obtain a uniform etch and phosphate coating growth on the base metal.

Steel

Cold extrusion has been carried out on most grades of steel with carbon contents up to 0.60%. The rapid work hardening property of the higher carbon steels is the limiting factor which determines the amount of cold work that can be accomplished in a single operation in a production set-up. Consideration of the finished product and the physical requirements will also aid in selection of the material.

In some instances, the authors point out, it may be desirable to take advantage of the high physical properties obtainable by a series of alternate cold work and annealing cycles. Parts produced in this way often compare favorably with parts machined from heat treatable alloys and hardened. Depending on the amount of cold work applied, the yield point of these annealed steels, ranging from 0.10 to 0.15 carbon, can be increased from 35,000 to 100,000 psi.

Most of the present work utilizes non-aging, aluminum killed steels of 0.10 to 0.20% carbon. Freedom from laps and seams is essential in most applications, and these defects should be ground out of the bar stock. In other applications where hot rolled surface defects may inter-

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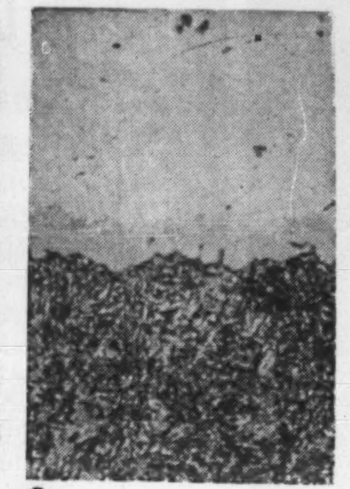

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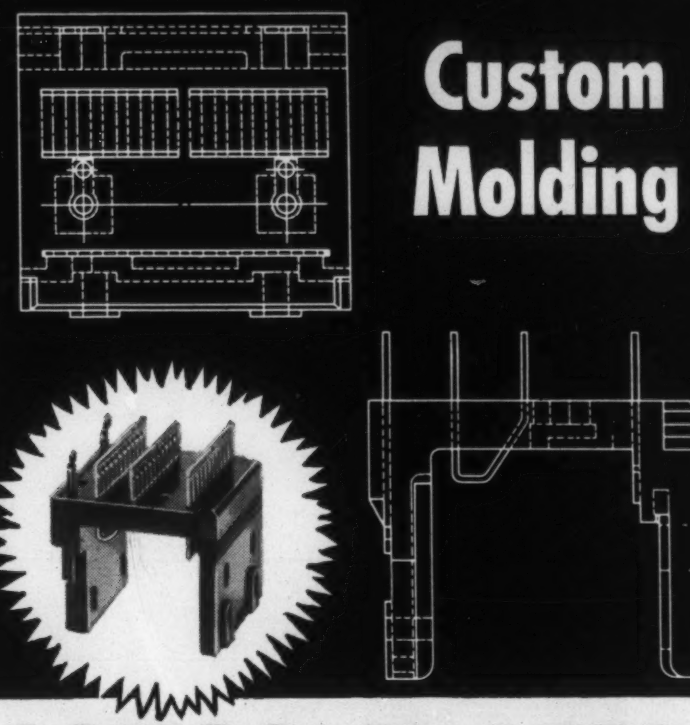

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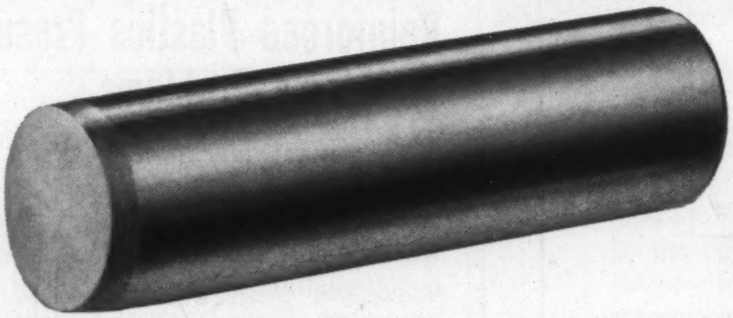

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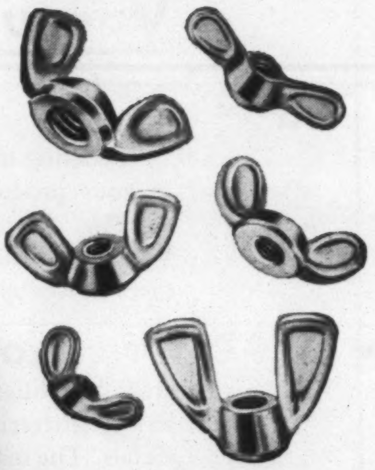

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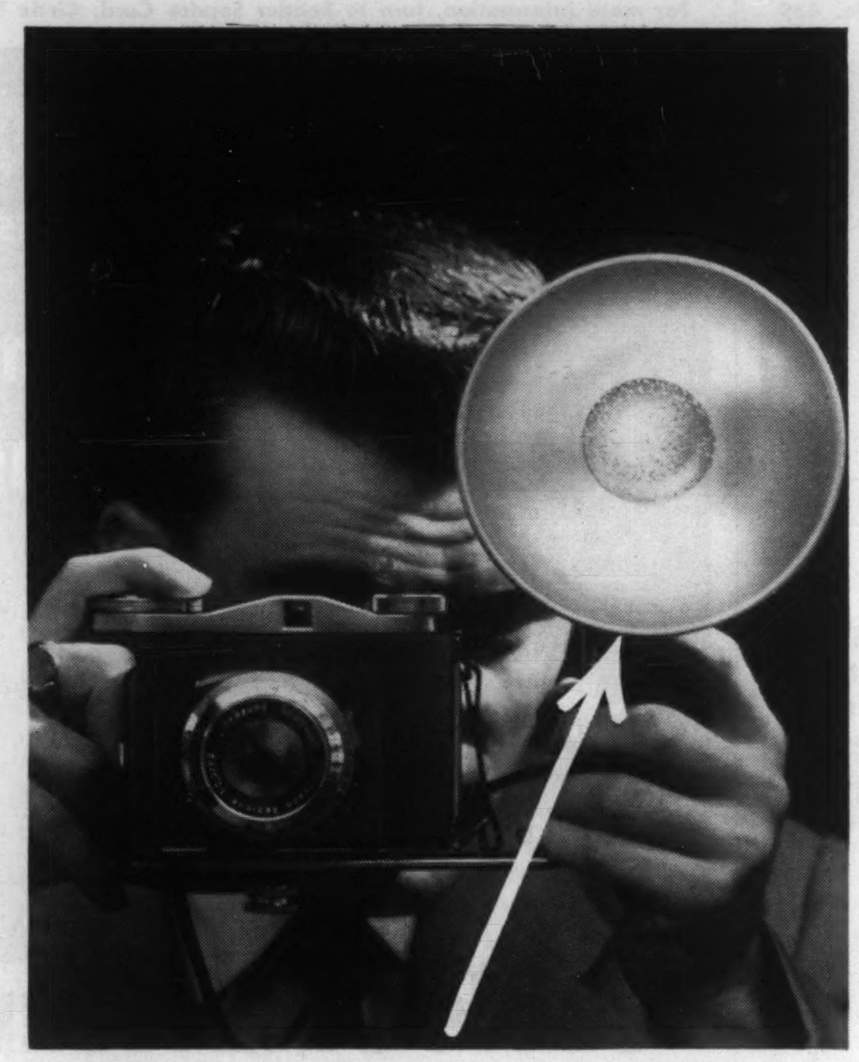

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fere with the requirements of the finished product, cold drawn and annealed bar stock may be used to advantage.

Aluminum

Aluminum is also coming into serious consideration as a raw material for cold extrusion. Lubrication has been found to solve many of the problems in cold working of work hardenable alloys. Oils and waxes frequently provide adequate lubrication in cold working of 2S, 3S and 52S, while with 14S, 61S and 75S a recently developed coating material, when used in conjunction with a reactive lubricant, has permitted the working of these alloys without the preheating operations. This special coating material, Bonderite 170, produces a crystalline, zinc phosphate coating on aluminum similar to that produced on steel.

In general, product and tool design considerations are the same for aluminum as they are for steel, though the lower pressing loads permit a greater latitude in producing a given shape. The age hardening tendency of some of these alloys produces no problems in compression forming, but may impose time limitations in ironing operations in order to avoid fractures. Often it is necessary to perform the drawing operations within an hour after the annealing operations.

Reinforced Plastics Present Machining Problems

In general, any material being cut by a machine tool or abrasive grain is subjected to mechanical forces which cause it to fail along predetermined lines. The efficiency of the operation depends on the resistance of the material to the tool.

In an article published recently in the *Proceedings of The Society of The Plastics Industry,* R. T. Argy, of The Carborundum Co., pointed out some of the machining problems inherent in glass reinforced plastics, and methods of overcoming them.

Hardness of Materials

When milling, sawing or drilling metal or some other homegeneous ductile material, the tool is appreciably harder than the material and shears through it, leaving a groove with smooth sides. This is not the

Contents Noted

continued

case with reinforced plastics. The tool may pass through the plastic portion with ease, but when it hits the glass fibers it tears its way through, leaving a ragged section in the wall of the groove. In addition to the poor condition of the cut, the dulling effect caused by the contact between the tool and glass, a material harder than the tool, must be considered.

Since a characteristic of glass reinforced plastics is their relatively low abrasion resistance, the author points out that most operations which can be performed with an abrasive tool can be done more efficiently in that way.

In backing up this statement Mr. Argy uses data reported by Johns Hopkins University, comparing the performance of a high speed steel circular saw with that of glass fabric-reinforced resinoid grinding wheel in the cutting of glass-melamine electrical laminates. The saw, costing about $17, performs for about 2 hr before resharpening. It may be resharpened some 25 to 30 times at $2 per sharpening. The abrasive wheel costs $2 initially, its effective life is also about 2 hr, and it removes in that time as much volume of material as the saw. In the sanding or grinding of materials such as metal, wood, protective and decorative coatings, and so forth, the life of an abrasive tool is limited by the loading of the cutting surface with chips of the abraded material. Except for instances where polyester resin surfaces are incompletely cured, this is not a serious problem in the machining of reinforced plastics. The dust is dry and does not smear over the abrasive. That which does accumulate is readily removed by a blast from an air hose.

Recommended Cutting Materials

Silicon carbide resinoid cut-off wheels are recommended for most major cutting, trimming and turning operations on glass reinforced-plastics. The cut-off wheels that should prove most useful are the glass-fiber reinforced and cotton fiber reinforced types. These have high strength, allow high speed cuts, and have longer life than metal saws.

For finishing operations on shaped parts, a sponge rubber disc with an abrasive sheet attached to the face allows the following of concave and convex contours with optimum contact between abrasive and plastic.

(Book Reviews on page 184)

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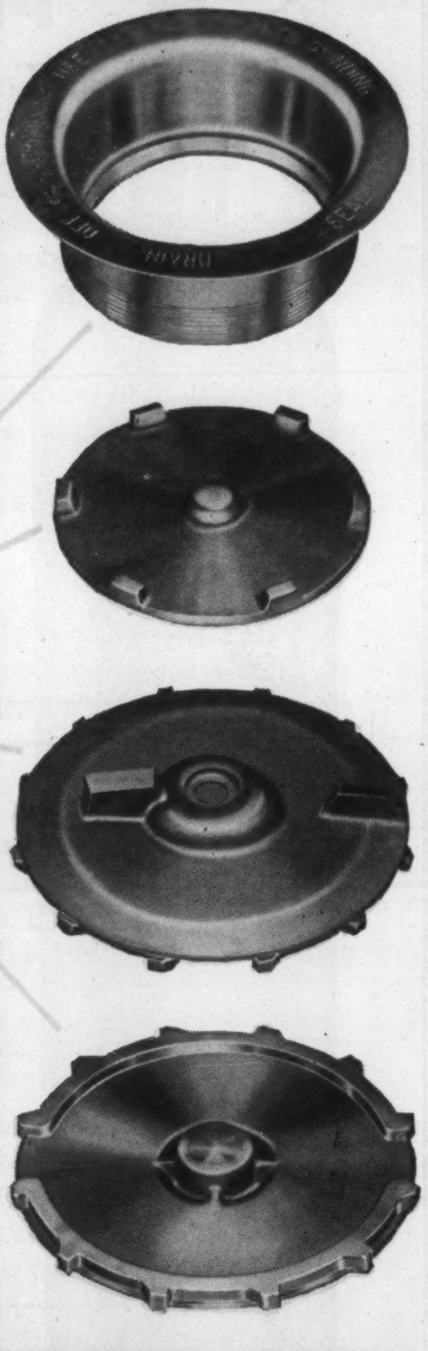

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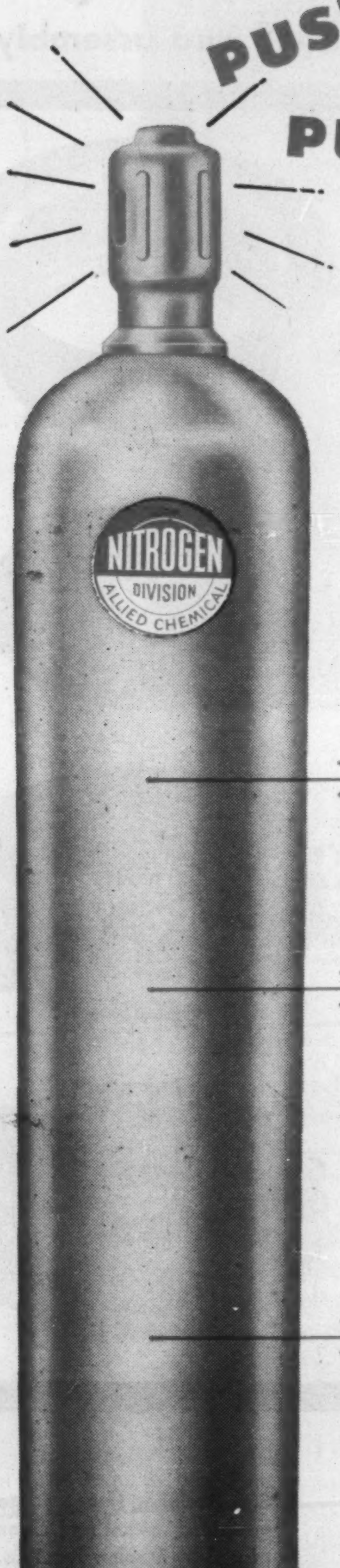

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FREE Technical Help. Technicians specially trained in the use of Anhydrous Ammonia for metal treating will help you. No obligation. Also, valuable handbook, "Guide to Use of Barrett Ammonia in Cylinders" shows most economical usage; contains chemical properties, handling, charts, etc.

FREE! Ammonia Leak Detector Safety Kit! Pocket-size, this new handy kit quickly detects ammonia leaks. May be used over and over. Write today!

NITROGEN DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.

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Contents Noted

Books

Fundamentals of the Working of Metals. *G. Sachs. Interscience Publishers, Inc., New York, N.Y., 1954. Cloth, 5-1/2 by 8-1/2 in. Price $4.75.*

This book consists of a compilation of articles which have been published previously in periodical form. It presents an elementary description of the basic phenomena which determine the performance of metallic materials on mechanical working.

The book is divided into six chapters covering effects of temperature and speed of forming, relationship between composition, structure and forming characteristics, effects of grain size, general concepts of metal forming, basic forming methods, and progressive fabrication.

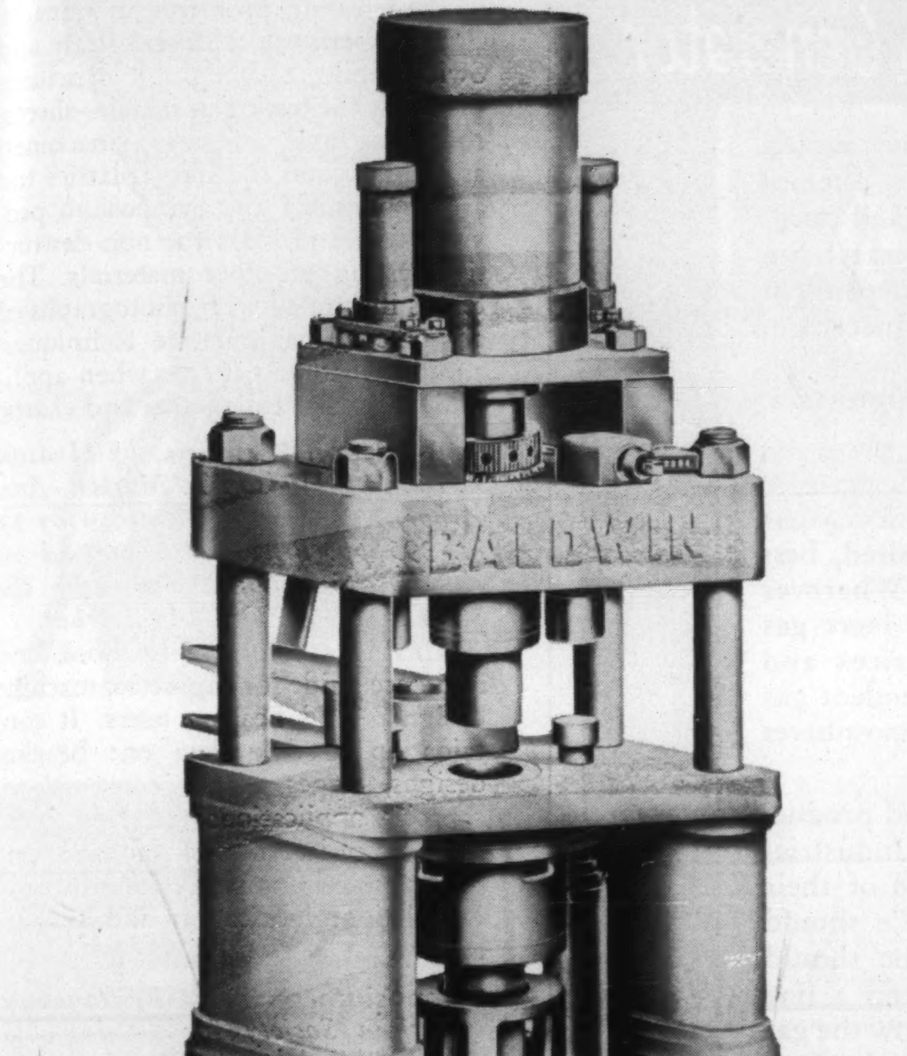
This volume will be particularly useful to the young engineer seeking a brief explanation of metal working processes and causes of failures during working.

Ferrous Process Metallurgy. *John L. Bray. John Wiley & Sons, Inc., New York, N.Y., 1954. Cloth, 6 by 9 in. 414 pp. Price $6.50.*

Concerned with the reduction and refining of metals, the subject matter in this text can be covered in a junior or senior course meeting three or four hours per week for a sixteen week semester. Much of the historical matter, properties of alloys, statistics of the industry, pricing system, and minor processes have been omitted from the presentation, but the instructor is urged to discuss these matters in class. Free use is made of physical chemistry in explaining the processes discussed and predicting future developments. Eight chapters cover: Raw Materials, The Iron Blast Furnace, Wrought Iron, The Bessemer Process, The Acid Open Hearth Process, Electric Furnaces and Ingots and Ingot Molds.

Symposium on Non-Destructive Testing. *American Society for Testing Materials, Philadelphia 3, Penna., Paper, 6 by 9 in. 105 pp. Price $2.00.*

Sponsored by ASTM Committee E-7 on Non-Destructive Testing, under the co-chairmanship of J. Smack of Sperry Products, Inc. and D. T. O'Connor, U.S. Dept. of the Navy, this Symposium was presented at the Fiftieth Anniversary Meeting of ASTM in June, 1952. The eight papers included here contain advanced non-destructive testing methods and



NEW BALDWIN MODEL "L"

50-ton powdered metal press offers you 8 exclusive features:

1. Hydraulic Head prevents overloading and prolongs the life of tools and press by controlling accurately the applied pressure.

2. Floating Die Holder and core rod float independently of each other against pneumatic cushions. The distance of movement is controlled by positive adjustable stops.

3. Fill Adjustment. Two separate controls adjust the depth of fill and stroke of the bottom punch.

4. Pre-Pressing Die Position Control maintains flange thickness, obtains uniform density and eliminates weld line when section changes.

5. Shuttle Type Feeder, air operated and cam controlled, carries the same volume of material over the die cavity each time. Spring loaded cutoff ring prevents loss of material.

6. Automatic Lubrication. All moving lubricated parts are completely enclosed and sealed so that abrasive material can not get into the bearings. All bearings subject to load are pressure lubricated. The press will not operate if there is no oil pressure in the lubricating system.

7. Variable Cycling with five options, as follows:
- Continuous run.
- Semi-continuous run with dwell—stop at any predetermined point—dwell—start automatically. Dwell time is adjustable.
- Single stroke—stop at any predetermined point—restart when operator pushes start button.
- Single stroke with dwell—combination of two preceding steps.
- Inching.

8. Quick, Accurate Adjustment permits changes in density or weight *while the press is in operation.*

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If you'd like to learn more about how the new Baldwin Model "L" can give you higher quality, lower-cost production, send for our new Bulletin 3104. Address, Sales Promotion Dept., Room 4923, Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

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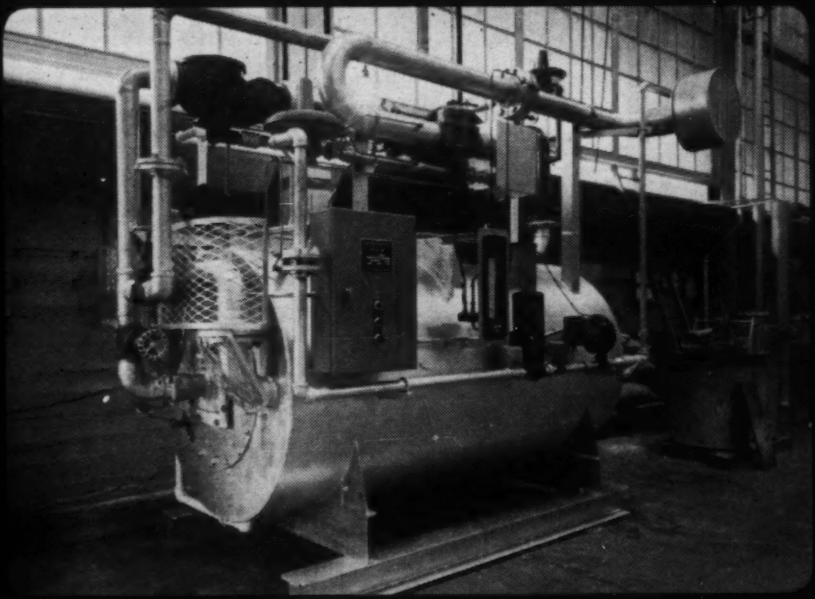
For more information, turn to Reader Service Card, Circle No. 431

"We Should Have Had This Years Ago," Said a U.S. Industrial Chemicals' Executive of a Gas Atmospheres' CO_2 Generator

Many chemical plants have a by-product supply of carbon dioxide gas which they often attempt to salvage and harness for blanketing and purging use within their own plant. However, relying on such a source is risky at best. It is dependent upon regular production of the product from which the gas is derived and subject to uncontrolled variances of gas purity and compression.

The Gas Atmospheres' compact, high efficiency, self-contained gas generators, that will produce any amount of atmosphere directly from city gas or oil, in the pressure and purity desired, best relieves this undesirable dependency. Wherever users of carbon dioxide, nitrogen or inert gas have heard the story, compared prices and weighed the advantages of this independent gas supply against any other source, Gas Atmospheres has been able to do business.

For example, after comparing costs and production figures, one executive of the U. S. Industrial Chemicals plant in New Orleans said of their new Gas Atmospheres' generator, "We should have had this years ago." Perhaps you should have, too. Why not find out? Just drop a line to Gas Atmospheres, Inc., and let us know the gas consumption you require and we'll work out a cost chart that will show you how this amazing generator will pay for itself in a few months.



gas Atmospheres, inc
equipment for producing industrial gases
20011 WEST LAKE ROAD CLEVELAND 16, OHIO

For more information, turn to Reader Service Card, Circle No. 394

techniques in use throughout the world and give a first-hand view of those used in solving specific non-destructive testing problems in Canada, France, Germany, Holland, Italy and Switzerland. Although it discusses primarily the testing of metal—sheets, rods, castings, forgings, machined assemblies, and the like (plastics too are mentioned) the Symposium provides data and ideas for non-destructive testing of other materials. The text is illustrated with photographs of equipment, manipulative techniques, and oscilloscope patterns when applicable, as well as diagrams and charts.

Anti-Friction Bearings. *by Hudson T. Morton. Hudson T. Morton, Ann Arbor, Mich., 1954. Cloth, 9 by 11 in. 395 pp. Price $7.75 prepaid on single copies. On 25 or more the price is $6.50 F.O.B. Ann Arbor.*

This is a complete textbook and reference guide for engineers, machine designers and bearing users. It contains up to date data on: bearing designs, types, load computation, capacity, applications, selection, identification code, tables of standard bearing sizes and numbers, mounting and installation, lubrication and bearing history.

Symposium on Light Microscopy. *American Society for Testing Materials, Philadelphia 3, Penna., 1953. Paper 6 by 9 in. 132 pp. Price $2.50.*

The papers contained in this Symposium, presented at the 55th Annual Meeting of ASTM, are representative of the applications of the microscope as a technical tool in a number of fields and the techniques of its use. There is a wealth of pictorial examples throughout the presentation and several of the papers include lists of references.

Reports

Investment Casting Carbon Steels
Investment Casting of SAE 1040 Steel. *U.S. Army Ordnance Corps. PB 111199, 22 pp. Available from U. S. Department of Commerce, Business and Defense Services Administration, Office of Technical Services, Wash. 25, D.C. $.50.*

Report is an excerpt from a longer report on the properties of these steels in investment casting, issued as PB 110463. Excerpt describes improvements in casting commercial carbon steels made possible by improving master pattern, and better methods

Powder-Cutting Saves $2,000

This 3-ton, 13-in. thick magnesium-bronze flywheel casting was reduced to furnace-charging size by powder-cutting in less than 8 hours. Previous methods required over 16 hr. to cut up a casting only 4-in. thick. Powder-cutting proved to be the most economical method for this job.

Powder-cutting replaced cold-sawing in this foundry operation, and did three times the cutting in half the time.

LINDE engineers were called in to help solve the problem of reducing giant flywheel castings to furnace-charging size. The castings had been part of an experimental program to develop accurately balanced flywheels for diesel engines. Test castings had to be cut for remelting.... But because of their great size, scrapping by formerly used methods would have been costly—if possible at all. LINDE advised powder-cutting.

In powder-cutting, a powdered metal is added to the oxygen stream to raise the temperature of the cutting flame, and increase the speed of the severing action. Among other things foundries are using powder-cutting to remove gates and risers from stainless steel castings, to wash away sand-incrusted casting surfaces, and for gouging out defects prior to repair welding.

LINDE service engineers will be glad to help you determine the best powder-cutting setups or other uses of the oxy-acetylene process for your needs.

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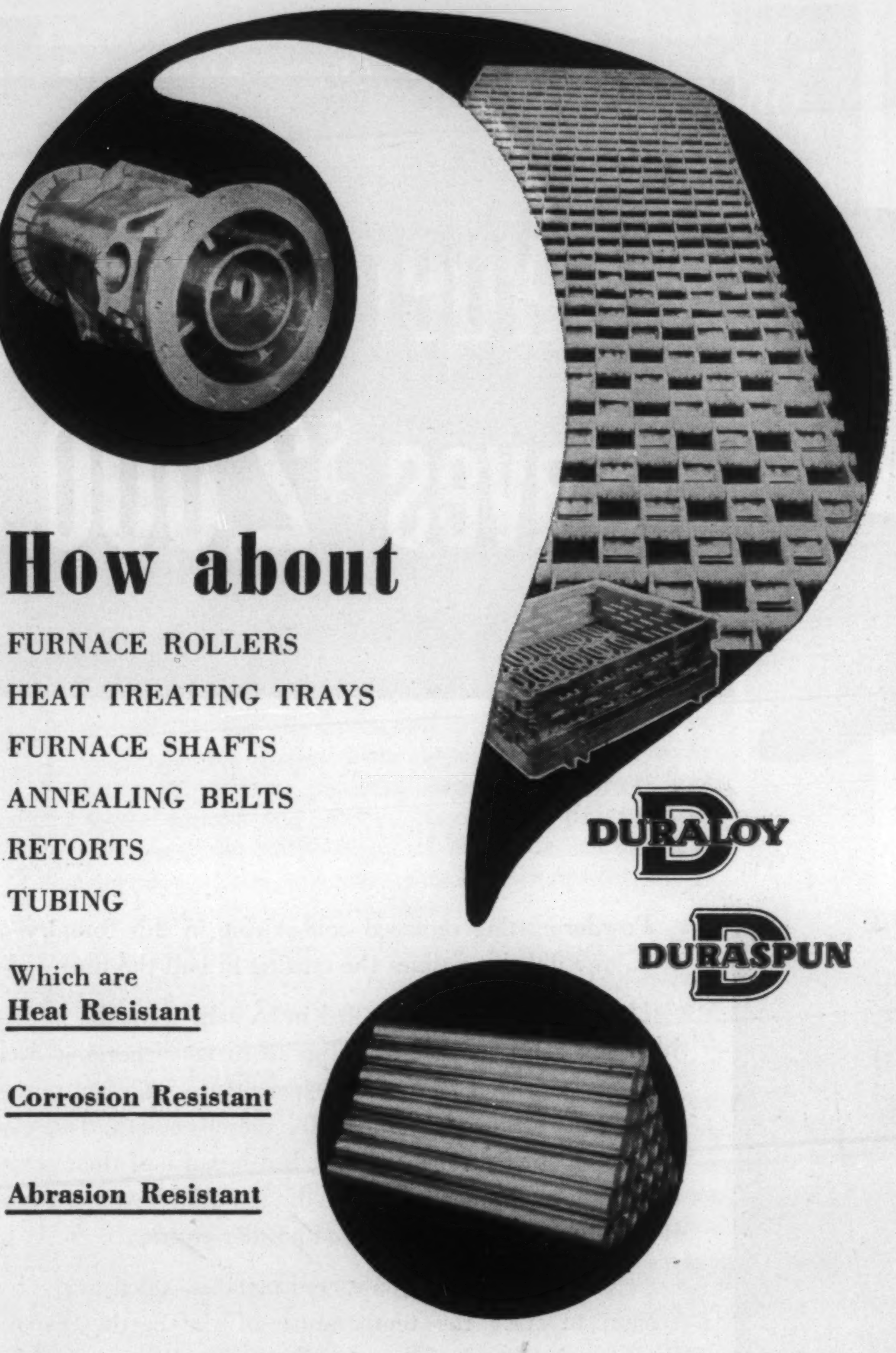

How about

FURNACE ROLLERS
HEAT TREATING TRAYS
FURNACE SHAFTS
ANNEALING BELTS
RETORTS
TUBING

Which are
Heat Resistant

Corrosion Resistant

Abrasion Resistant

When ready to order, how about checking with us here at DURALOY? For more than thirty years we have specialized in high-alloy castings. In fact, we were among the first to produce static castings and the first to produce centrifugal castings. We are old hands at producing castings alloyed to fit each specific requirement and to finish them to any extent desired.

Melt, castings and finishing are carefully controlled and quality tested by our staff of metallurgists, chemists, X-ray and gamma-ray technicians. If you would like more preliminary information, send for Bulletin No. 3150-G.

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Contents Noted | Reports continued

of pouring bismuth mold halves and joining expanded wax patterns.

Brazing Survey Literature Review and Industrial Survey of Brazing. *Armour Research Foundation, for U.S. Army Ordnance Corps, Final Report, June 1952. PB 112027, 193 frames. Available from Library of Congress, Photoduplication Section, Wash. 25, D.C. Microfilm $7.00, Enlargement Print $26.25.*

This review of recently published brazing literature describes successful brazing techniques for assemblies in many possible designs and materials. Covers the behavior of ferrous and nonferrous metals under various brazing techniques, chief characteristics of brazing alloys and their melting and capillary flow ranges, bonding strength, and wetting and covering power.

Nitric Acid vs Metals Materials for Handling Fuming Nitric Acid. *Wright Air Development Center. PB 110963, 109 pp. Available from Library of Congress, Photoduplication Section, Wash. 25, D.C. Microfilm $4.50, photostat $13.75.*

Report discusses effect of white and red fuming nitric acids on a number of metals and alloys. Describes the results of stress corrosion of stainless steel, the nature and mechanism of knife-line attack, the effect of additives upon the acids, and the galvanic couple system.

Corrosion Resistant Paints Butyl Titanate Heat and Corrosion Resistant Paints. *Defense Research Laboratories, Maribyrnong, Victoria. PB 110900, 22 pp. Available from Library of Congress, Photoduplication Section, Wash. 25, D.C. Microfilm $2.00, photostat $3.75.*

Applications and formulas are described for paint films that are dry and hard enough to handle after 30 min. Paints are derived from the direct preparation of polymeric butyl titanate from titanium tetrachloride and aqueous butanol. Polymers made with the recommended proportions of water and $TiCl_4$ are considered highly suitable for paint vehicles. Conclusion is reached that there is ample justification for commercial production of butyl titanate polymer as a protective covering against both corrosion and heat.

Glass—Plastic Laminates In Aircraft Developments Concerning Aircraft Glass Fiber Plastic Laminates. *Wright Air Development Center,*

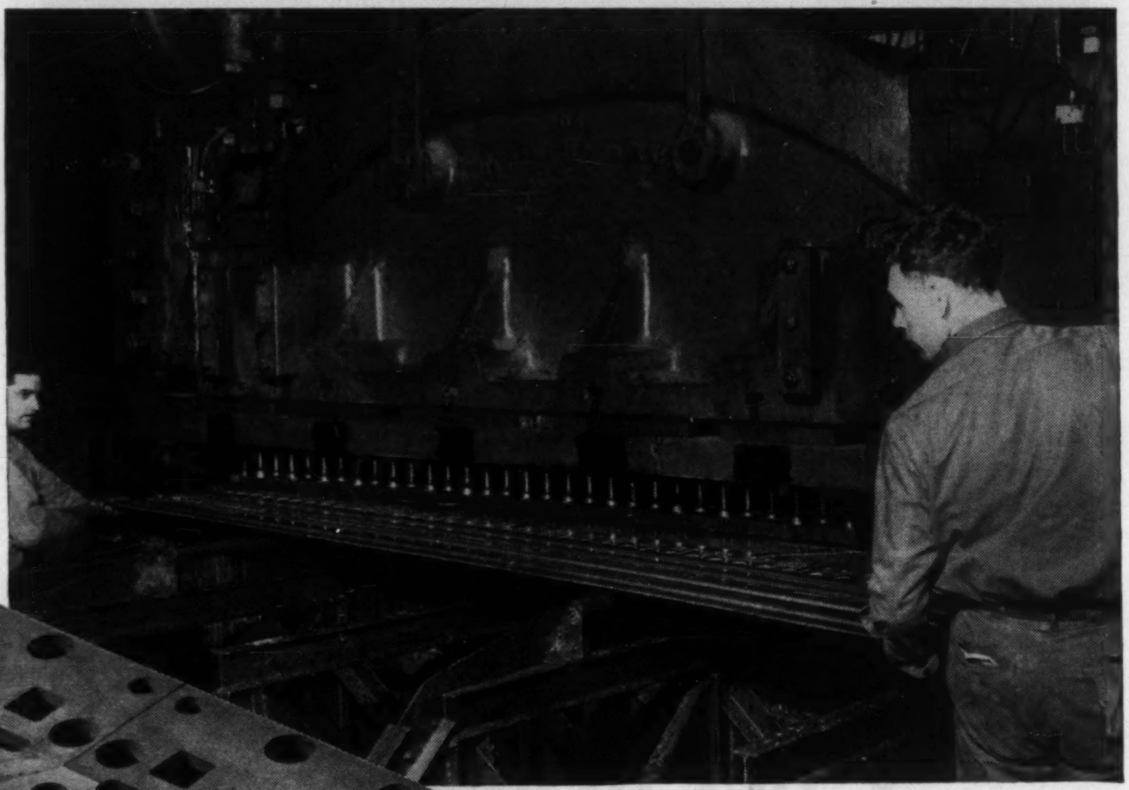
Tool Steel Topics

BETHLEHEM STEEL

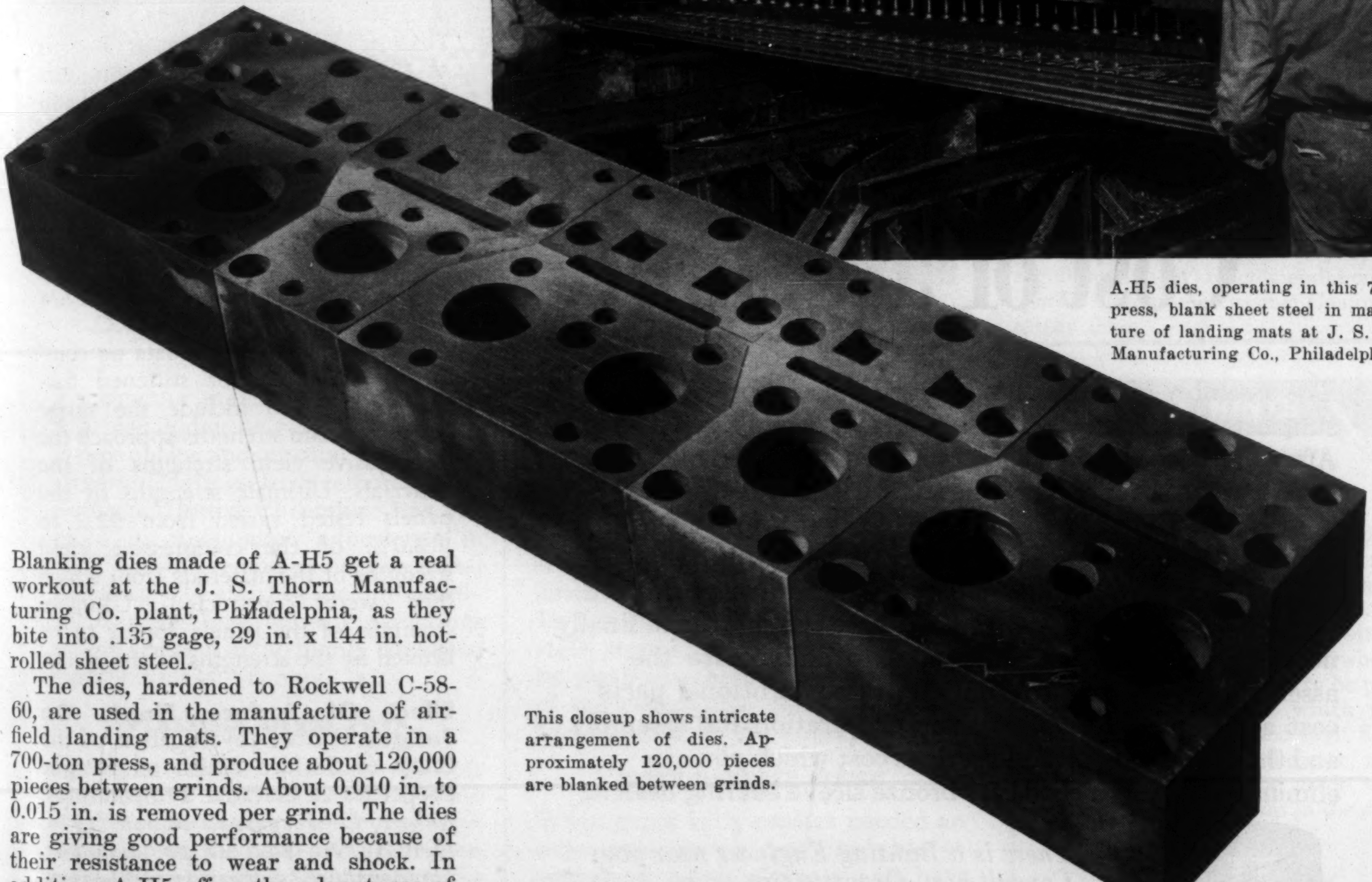
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

Dies of A-H5 ive Good Service in Turning Out Landing Mats



A-H5 dies, operating in this 700-ton press, blank sheet steel in manufacture of landing mats at J. S. Thorn Manufacturing Co., Philadelphia.



This closeup shows intricate arrangement of dies. Approximately 120,000 pieces are blanked between grinds.

Blanking dies made of A-H5 get a real workout at the J. S. Thorn Manufacturing Co. plant, Philadelphia, as they bite into .135 gage, 29 in. x 144 in. hot-rolled sheet steel.

The dies, hardened to Rockwell C-58-60, are used in the manufacture of airfield landing mats. They operate in a 700-ton press, and produce about 120,000 pieces between grinds. About 0.010 in. to 0.015 in. is removed per grind. The dies are giving good performance because of their resistance to wear and shock. In addition, A-H5 offers the advantages of low distortion, and ease of machinability and heat treatment.

A-H5 is our 5-pct-chrome air-hardening tool steel. It's an easy tool steel to machine, too, as it can be annealed to 212 Brinell.

Typical Analysis

Carbon	1.00	Molybdenum	1.10
Manganese	0.60	Vanadium	0.25
Chromium	5.25		

A-H5 is an economical steel for dies, punches, and forming and blanking tools. It is well liked wherever safe hardening, low distortion and increased resistance to wear are required. Why not give it a trial? Your nearest Bethlehem tool-steel distributor can supply you promptly.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Avoid Premature Failure—Don't Make Shock Tools Too Hard

As a rule, shock-resisting tool steels perform best when they are hardened to Rockwell C-55/C-60. At such a range, there's a good compromise provided between toughness and resistance to wear. When premature failure occurs in these grades, it can usually be traced to excessively high hardness.

But rather than harden shock-resisting steels to Rockwell C-59 or higher, when such hardnesses are required, it would be better to select a carbon tool steel.

When greater wear-resistance is required, the chrome-tungsten grades of shock-resisting tool steel may be carburized to provide a hard case and a shock-resisting core. The carburized case used for this type of shock-resisting steel should be only 0.010 deep. This method can be used to good advantage when you are manufacturing such items as reamers, swaging dies and master hobs.

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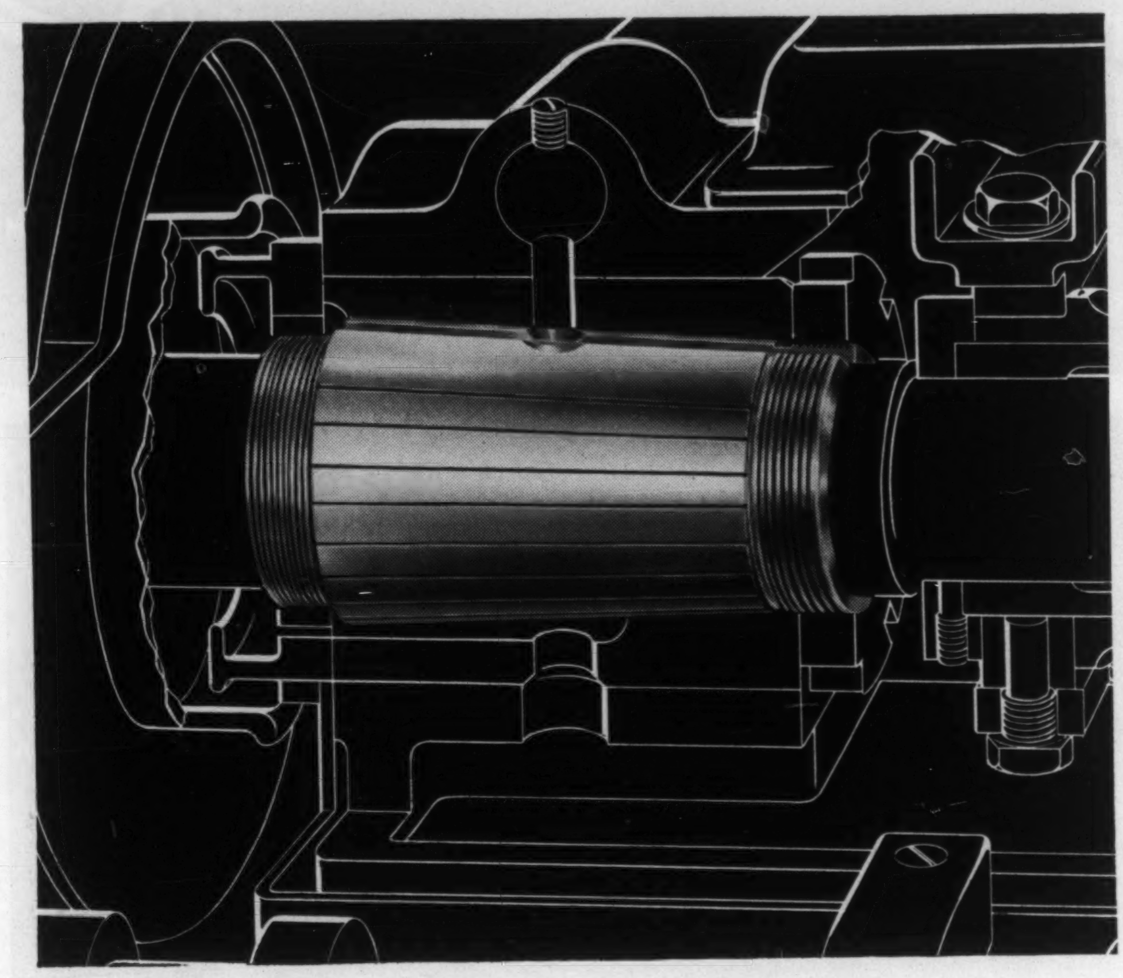

THE WAY TO CUT...
Cost of assembly

The assembly of a unit equipped with sleeve bearings is the simplest, easiest, most understandable assembly possible. After the sleeve bearing has been assembled in the housing or other part that supports it, the shaft which is to operate in it is simply inserted in the bore of the bearing. There is no inboard end cover to assemble on the shaft first, no bearing to be pressed against the shaft shoulder, no lock nut or lock washer to lock the bearing to the shaft, and finally no outside end cover or enclosure to add before the assembly is complete. Not only do these additional parts cost additional money but their preparation for assembly and the actual assembly add serious cost which you can eliminate by using a good cast bronze sleeve bearing design.

There is a Bunting Engineer near you. Consult him. Or write our Product Engineering Department at Toledo.

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BRONZE BEARINGS • BUSHINGS • PRECISION BRONZE BARS

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July 1952. PB 112387, 176 pp, Photographs, diagrams, graphs, tables. Available from Library of Congress, Publication Board Project, Wash. 25, D.C. Microfilm $6.50, photostat $22.50.

Contains sixteen reports on recent developments in aircraft glass fiber plastic laminates. Concentrating on structural applications, papers review latest technology of heat resistant polyester, silicone and phenolic laminates, including the effect on these materials of fatigue, preloading, direction of stress and defects. Information is given on the new sizings for glass fibers for improved-strength polyesters, and special attention is given developments of high strength epoxide laminates.

Testing Sheet Aluminum Results of Edge-Compression Tests on Stiffened Flat-Sheet Panels of Alclad and Nonclad 14S-T6, 24S-T3, and 75S-T6 Aluminum Alloys. *Marshall Holt, Aluminum Company of America, April 1954. NACA TN 3023, 18 pp, diagrams, photographs, 2 tables. Available from National Advisory Committee for Aeronautics, 1724 "F" St., N.W., Wash. 25, D.C.*

The report augments data on compressive strengths of stiffened flat-sheet panels to include the range where ultimate strengths approach the compressive yield strengths of the materials. Ultimate strengths of the panels tested varied from 92.2 to 118.0% of the compressive yield strengths of the materials from which they were constructed. Ultimate strengths of the panels appear to be limited by the strengths of the rivets.

Effect Of Surface Finish On Fatigue Further Investigation of the Effect of Surface Finish on Fatigue Properties at Elevated Temperatures. *Robert L. Ferguson, March 1954. NACA TN 3142, 27 pp, diagrams, photographs, 3 tables. Available from National Advisory Committee for Aeronautics, 1724 "F" St., N.W., Wash. 25, D.C.*

Report evaluates the effects of surface roughness on fatigue properties on low carbon N-155 alloy (grain size ASTM 6) and of S-816 alloy (grain size ASTM 6 to 7). Studies were conducted at 80, 1200, 1350, and 1500 F. Also effects of surface abrasion on residual stress and effect of time and temperature on relief of these stresses was studied.

UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic .... Organic .... Decorative .... Protective

New-type coatings end tough finishing problems

Unique groups of Unichrome Organic Coatings meet tough specifications—deliver unusual performance

United Chromium cooperates in working out answers to service and production requirements for metal finishes.

DIFFICULT metal coating problems can today be readily solved by means of new and unusual Unichrome Organic Coatings. In developing these coatings, United Chromium has applied its unequalled experience in both decorative and protective metal finishing. The finishes include plastisol coatings; eye-appealing coatings which are also in the highly corrosion resistant class; primers.

PLASTISOL USAGE PAYS

Unichrome Vinyl Plastisols deliver the unique combination of wide chemical resistance, resiliency, thick build-up on the part, and seam-free, pore-free protection. A pioneer in the field, United Chromium has developed many of these compounds to suit special needs.

Various types available now include practical *sprayable* compounds which deliver films up to 25 mils thick in a *single* sag-free coat. Other formulations allow application by dip, knife, roller, and slush coating.

Now being used to solve many difficult problems, these coatings are establishing remarkable service records. For example: Unichrome Plastisol Coating still looked fine after 2 years on commercial dishwasher baskets, whereas no previous coating had survived even that long. In another case, half-ton stainless steel strainer bodies were replaced by plastisol-coated cast iron because of the remarkable chemical protection afforded by the finish.

MORE DURABLE FINISH

When metal milk coolers needed an attractive finish, yet one able to withstand harsh cleaners and high humidity encountered in dairies, a Unichrome Coating System proved best. Only required to pass 600-hour, 100° F, 100% relative humidity test, it remained unaffected for 3400 hours.

Another concern simulated gold parts for refrigerator trim with polished stainless steel and a Unichrome Transparent Tinted Enamel—which passed the 500 hour heat and humidity test and was still going strong 11,850 hours later.

PRIMER FOR LIGHT METALS

Wider use of magnesium and aluminum can now be made because finishing them need no longer be a problem. Unichrome Primer AP-10 assures dependable adhesion of top coats to these active metals. Rigorous tests by large metal producers proved it, usage has confirmed it.

* * * *

These coatings exemplify a few of the latest type specialized coatings United Chromium has developed to deliver exceptional performance on metal products. Send in the details on your own requirements for recommendations on specific Unichrome Organic Coatings to satisfy them.

UNITED CHROMIUM, INCORPORATED

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Chicago 4, Ill. • Los Angeles 13, Calif. • In Canada: United Chromium Limited, Toronto, Ont.

HELPFUL HINTS
by "Mr. Cost Cutter"

The shape of a piece can greatly affect the uniformity of its plated finish—sometimes even determines whether it can be economically plated at all. It pays, therefore, to check with the finishing department to learn whether any newly designed part to be plated will create problems which could cause many rejects and high finishing costs. If such is the case, minor changes can often be made which will avoid the problems in the *design* stage.

More tolerant nickel bath = more output

A plant installed the Unichrome Bright Nickel process alongside a larger tank of another nickel solution. Both plated identical parts. Yet Unichrome Nickel turned out more work. It tolerated impurities so much better that it took less time for purification. Now it occupies both tanks. Ask for bulletin NI-1.

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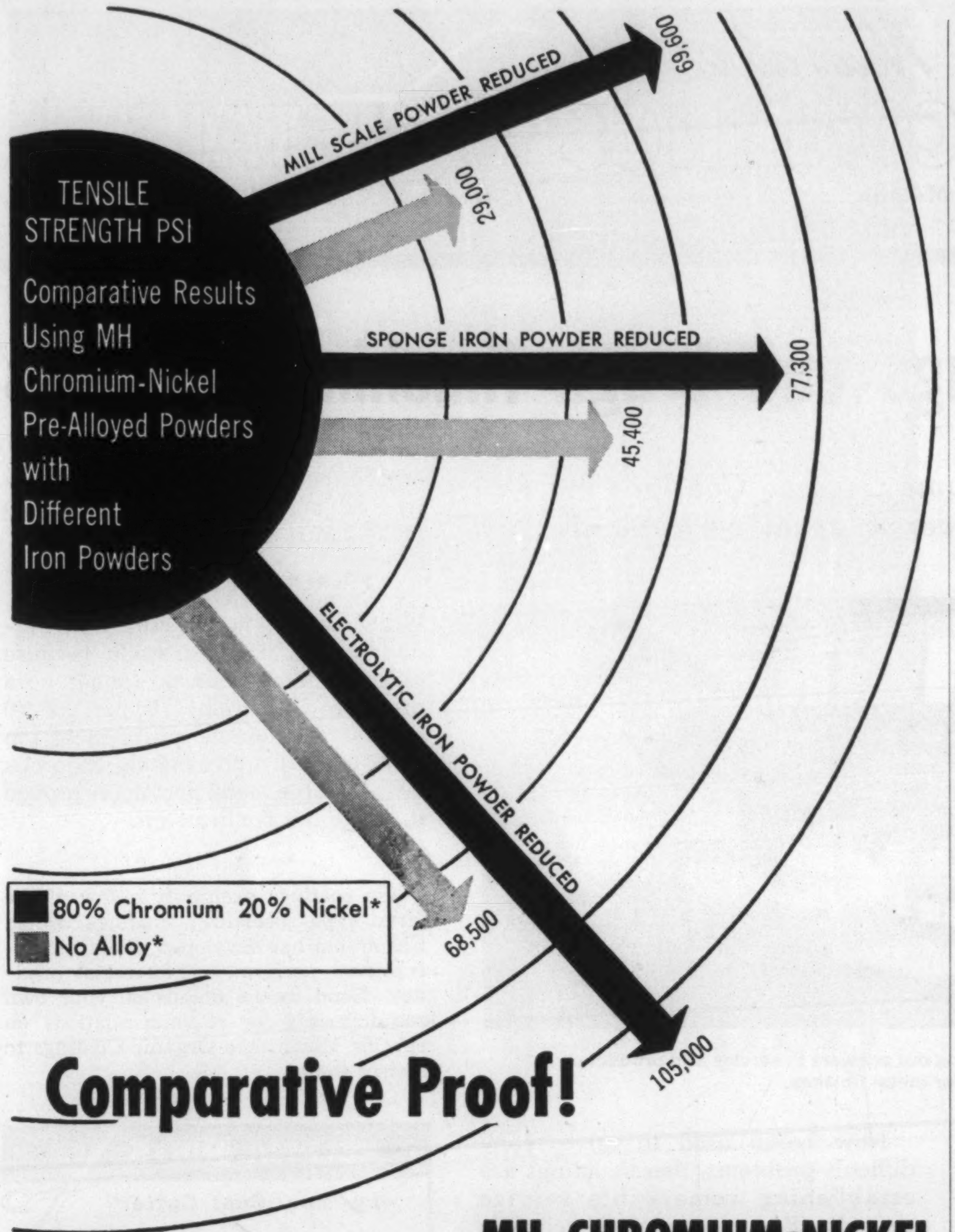

Comparative Proof!

*1% carbon added

MH CHROMIUM-NICKEL Pre-alloyed Powders Assure

The Tensile Strength Your Compact Must Have

Regardless of size, your compact will have greater tensile strength if you combine small amounts of Metal Hydrides' chromium-nickel pre-alloyed powders with iron powders.

The comparative results shown in the above chart indicate the highly satisfactory results that can be expected. You are invited to write now for further information . . . your inquiry will receive prompt, interested attention.

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16 CONGRESS ST., BEVERLY, MASS.

For more information, turn to Reader Service Card, Circle No. 445

news of ENGINEERS COMPANIES SOCIETIES

News of Engineers

David Mayers, works manager, Kaiser Aluminum & Chemical Corp.'s sheet plate rolling mill at Trentwood, Wash., has been appointed manager of the company's foil and sheet expansion plants. **Marvin L. Lee,** who has been works manager of the company's extrusion plant at Halethorpe, Md., succeeds Mr. Mayers.

Paul S. Landis has been appointed assistant manager, sheet and strip products, Jones & Laughlin Steel Corp.

Frank W. Davis, formerly assistant to Convair's vice president-engineering, has been named chief engineer of Convair's Fort Worth Div. Mr. Davis replaces **J. W. Larson,** who has resigned.

B. P. Finkbone, product engineer, Research Div., Armco Steel Corp., was the recent recipient of the annual award of the Galvanizers Committee.

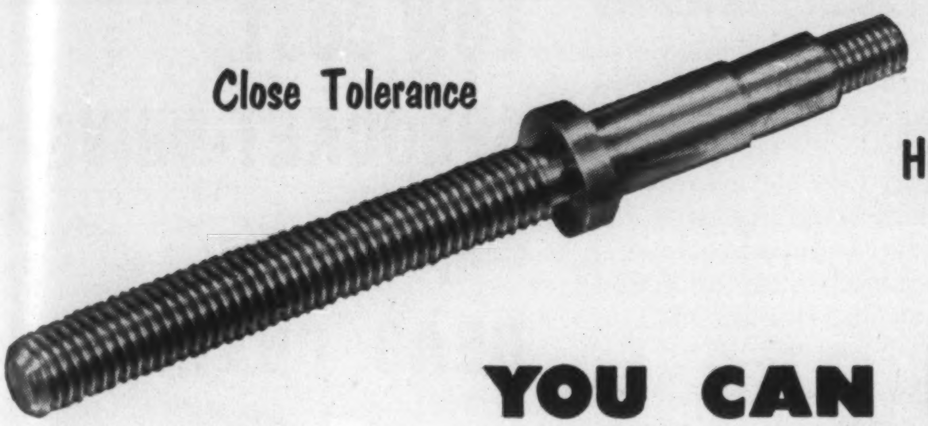
W. M. Hurley has been appointed general manager of the Arms and Ammunition Div., Olin Industries.

Frederick W. McIntyre, Sr., president, Reed-Prentice Corp., has been elected chairman of the board of that company and **Frederick W. McIntyre, Jr.,** vice president, will assume the position of president. **Donald H. Dalbeck** was elected a director and vice president and **Iver G. Freeman** was named as vice president.

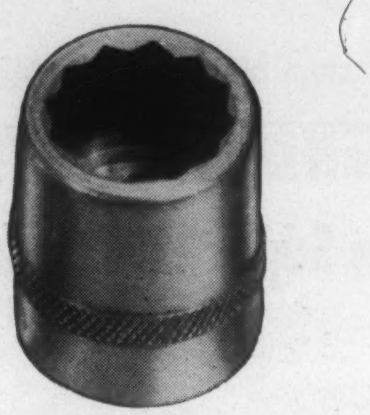
James R. Longwell, assistant to the general manager of Carboloy Dept., General Electric Co., has announced his retirement from the organization. Mr. Longwell has formed Longwell Engineering-Sales Co., engineering and sales consultants.

E. Raymond Engstrand has become chief metallurgist at Ferro Powdered Metals, Inc., after having served in the same position with Yale and Towne Mfg. Co., American Sintered Alloys, Inc., Maguire Industries, and the Auto-Ordnance Corp. of Bridgeport, Conn. **John W. Polonetz** has been named chief development engineer and **Joseph W. Farmer** has assumed the position of chief engineer.

(Continued on page 194)

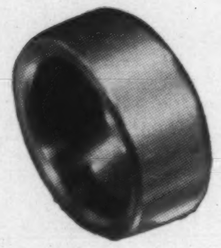


Close Tolerance

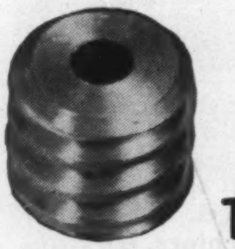


High Strength

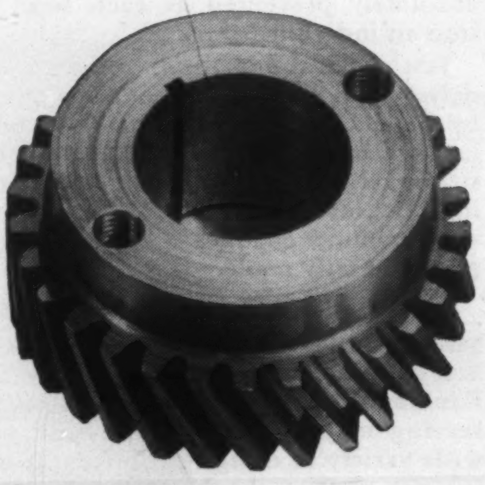
YOU CAN HAVE ALL SIX ... PLUS *Uniform Machinability*



Fine Surface



Toughness



Hardenability

Maybe you want some of these properties in your steel parts. Or a combination of them. Or only one.

No matter which ones you need, you get them—plus *uniform machinability*—in Republic Cold Drawn Steels.

That's why so many manufacturers have come to Republic with their machining problems. Manufacturers whose costs and production records show their automatics aren't turning out what they could.

Republic's 3-D Metallurgical Service focuses the combined experience of the Field, Mill and Laboratory on your particular problem. And the recommendation you get is based on your plant, your product, and your equipment.

There's no reason to deny yourself this service. It costs only the price of a phone call to your nearest Republic office. And it can save you a lot. Do it today.

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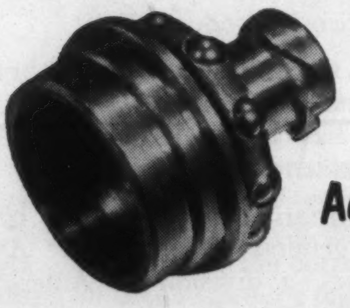

Accuracy of Section

REPUBLIC COLD DRAWN
ALLOY STEEL BARS

Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Bars, Wire, Pig Iron, Steel and Plastic Pipe, Bolts and Nuts, Tubing

For more information, turn to Reader Service Card, Circle No. 351

On any steel blackening problem

DEPEND on DU-LITE for a Superior Finish

Here's an example . . .

Courtesy The Poly Choke Co.

Du-Lite gave this part with its complicated knurls, slots, threads, etc. a fine rust-resistant durable black finish. It is typical of many other parts, small and large, which have been black oxidized by Du-Lite for many years. Moreover, Du-Lite meets most individual and government specifications including 57-0-2C for Type III Black Oxide finish.

Typical Du-Lite installation

Du-Lite installations are simple, compact, easy to operate. Du-Lite equipment can be tailored to fit production requirements on all types of jobs with a maximum of speed and economy. Du-Lite also makes a complete line of cleaners, strippers, wetting agents, passivating agents, rust preventatives, burnishing compounds etc. for any metal finishing application.

See your nearest Du-Lite Field Engineer or write for more information.

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METAL FINISHING SPECIALISTS

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news of | ENGINEERS

John A. Bennett, National Bureau of Standards, has received the Department of Commerce Silver Medal for Meritorious Service. The award was made for "very valuable contributions in the field of metallurgical science and technology, with particular referance to the mechanism of fatigue failures in metals, and for meritorious authorship".

Glenn Crawford, executive vice president, Dunlop Tire and Rubber Corp., has been promoted to the presidency of that company. Mr. Crawford succeeds **David B. Collett,** who has served as acting president since last September when **Edward B. Germain,** former president, was granted a leave of absence. Mr. Collett, a director of Dunlop Rubber Co., Ltd., of London, continues as director and vice chairman of the American company while Mr. Germain continues to serves in an advisory capacity.

J. W. McMullan, general manager of Pittsburgh Works, Allis-Chalmers Manufacturing Co., has been named vice president in charge of transformer and switchgear equipment.

Charles E. Reed has been appointed manager of material and method engineering, a new division of the Procurement Dept., at Magna Engineering Corp.

W. J. Thomas, general manager of the Tubular Products Div., The Babcock & Wilcox Co. has been named a vice president of the company.

Dr. Robert O. Sauer has been named manager of a new Advance and Development Unit within the Engineering Section, General Electric Co.'s Silicone Products Dept.

W. J. Cook has been named president, Hunter Spring Co., and **P. C. Clarke** has been elected executive vice president of the company.

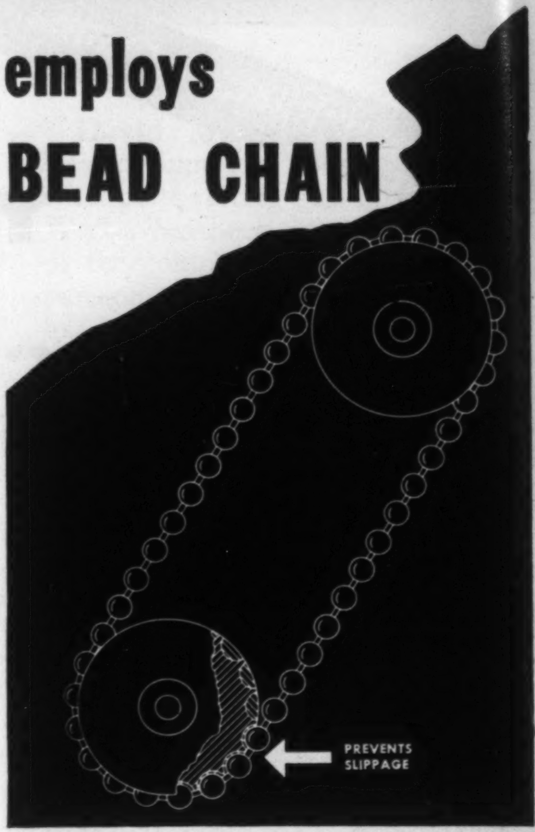
J. Gilman Reid, Jr. has been named general manager of ACF Electronics, a division of American Car and Foundry Co.

Charles F. McCabe and **Joseph H. Famme** have been appointed assistant chief engineers, San Diego Div., Consolidated Vultee Aircraft Corp.

R. E. Workman has been named assistant to the general manager, Chemical Div., The Goodyear Tire & Rubber Co.

(Continued on page 196)

EFFICIENT, LOW-COST SPROCKET-DRIVE employs BEAD CHAIN



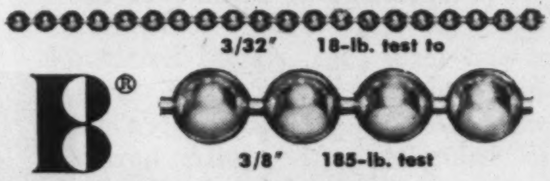
Because of its unique characteristics, Bead Chain is frequently employed by alert designers to make a simple, low-cost and highly efficient sprocket drive. Ideal for many products, it has been proved on business machines, television tuners, venetian blinds, etc. Slippage is absolutely prevented as each bead fits into an individual pocket.

Just check the qualities you want in a drive chain against the qualities offered by Bead Chain: It will not kink, bind, jam or shrink. It is completely flexible, strong, light, rustproof and long-wearing. Because every bead acts as a universal joint, changes in direction of pull are easily made.

SOLVES MANY DESIGN PROBLEMS

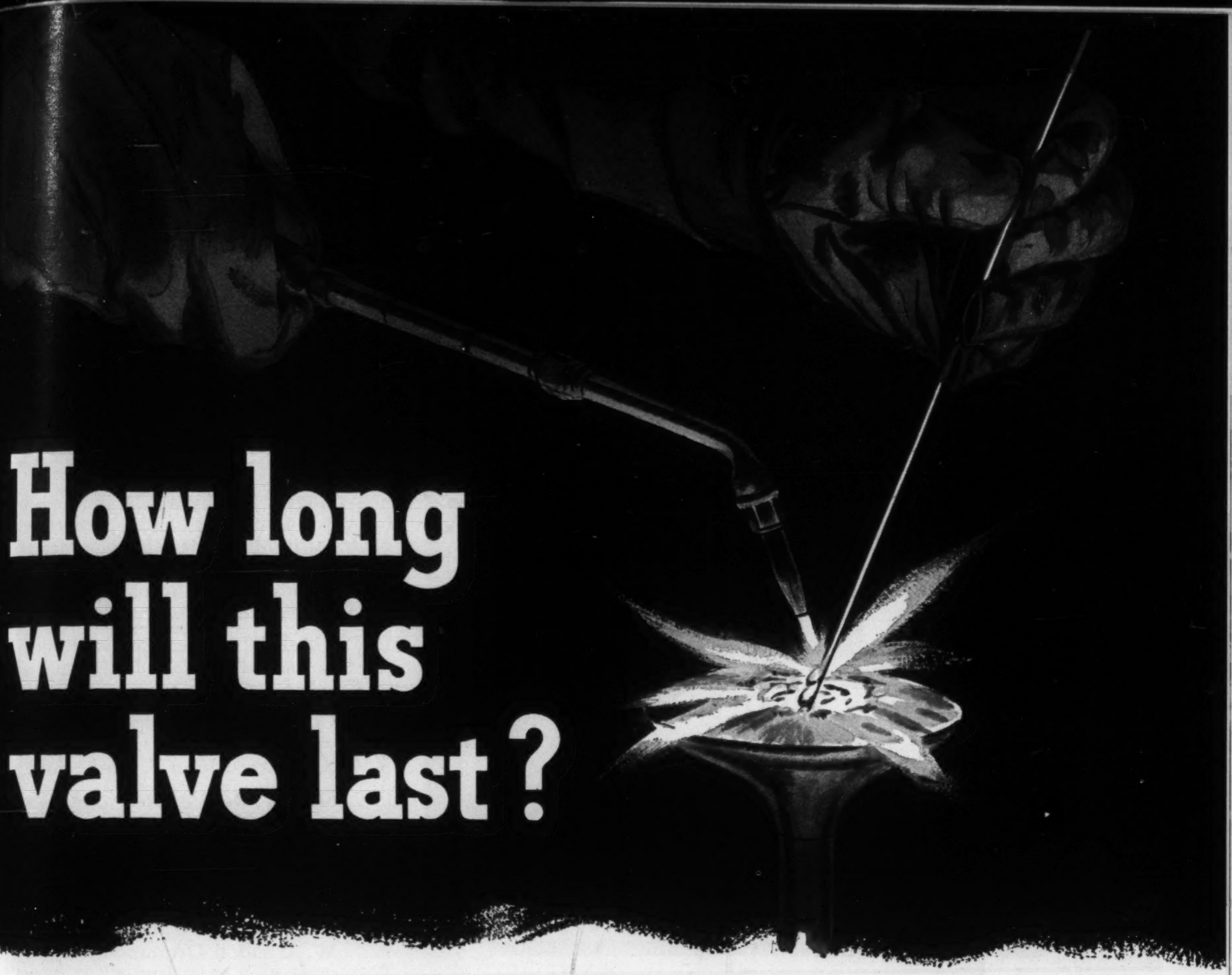
BEAD CHAIN — the chain you think of first as an electric light pull is truly "the Kinkless Chain of a Thousand Uses" — serving many industries and solving a wide variety of design problems. It may pay you well to check your product for opportunities to reduce costs and add sales appeal with this unique chain.

Bead Chain is available in many metals and finishes, and in five sizes, from:



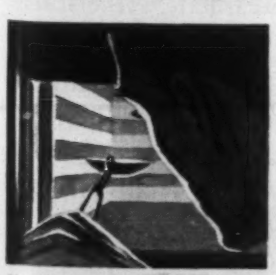
The BEAD CHAIN® Mfg. Co.
15 Mountain Grove St., Bridgeport 5, Conn.
Manufacturers of: BEAD CHAIN — the kinkless chain of a thousand uses, for fishing tackle, novelty, plumbing, electrical, jewelry and industrial products; MULTI-SWAGE — the most economical method of producing small tubular metal parts for electronic and mechanical applications.

For more information, Circle No. 474



How long will this valve last?

Hoskins Chromel-Alumel thermocouple alloys accurately register exhaust temperatures of jet aircraft engines.



Heating elements made of Hoskins Chromel give long life service in industrial electric furnaces, home appliances.

Hot stuff for hot jobs! Hoskins Alloy 502 is widely used by industry for many heat resistant mechanical applications.

You're looking in on a life-saving operation . . . one that's being performed on an engine valve. Not an ordinary valve for an ordinary engine. But a valve destined for long, hard service in an aircraft, tank, or heavy-duty truck engine. A valve that must be made to stand up under extremely severe operating conditions . . . high temperatures, for long periods of time, plus the destructive corrosive action of hot exhaust gases.

And what's responsible for long valve life under such gruelling conditions? Nothing less than Hoskins Alloy 717 . . . a closely controlled nickel-chromium composition developed especially for just such tough and vital service. It's highly resistant to heat . . . immune to the corrosive atmospheres created by combustion of high octane fuels. What's more, it's readily applied by fusion to form a non-porous protective facing over the basic valve forging.

But 717 is only one of several specialized nickel-chromium alloys developed and produced by Hoskins. Among the others: Alloy 502 . . . known throughout industry for its dependability on a wide range of heat resistant mechanical applications. The Chromel-Alumel thermocouple alloys . . . unconditionally guaranteed to register true temperature–E.M.F. values within specified close limits. Spark plug electrode alloys which have become universally accepted standards of quality and durability. And, of course, there's Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.

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MANUFACTURING COMPANY
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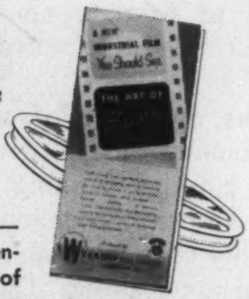

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Cold finishing provides the accurate dimensions and shape, the cold worked grain structure and the excellent finish you are accustomed to, but with Wyckoff *Furnace Treatment* you get all these *other* desirable properties in addition.

Yes, when you want the finest in cold finished steel, look to Wyckoff for the *specialized* processing that emphasizes *every* quality characteristic of fine cold finished steels. Specify Wyckoff *Furnace Treated* Cold Finished Steel Bars and be sure.

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Turned and Ground Shafting • Wide Flats up to 12" x 2"
All types of furnace treated Steels

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news of ENGINEERS

Edwin Y. Bready has been named manager, Hollowell Pressed Steel Div., Standard Pressed Steel Co., and **James L. McDowell** has been named superintendent of manufacturing, Fastener Div.

Marmion S. Oldacre, former director of research, Commonwealth Edison Co., has joined the senior scientific staff of Stanford Research Institute.

Roger J. Hayes has been promoted to manager of staff production research, Minnesota Mining & Manufacturing Co., and **A. C. Boyden** has been promoted to manager of staff production industrial engineering.

Ralph Winslow has been named departmental vice president, Koppers Co., Inc.

George S. Mikhalapov has been elected president of Coast Metals, Inc. to succeed **John P. Rutherford.**

Dr. T. M. Vial has joined the new product development department, American Cyanamid Co.

John W. Gosselin has been elected vice president, The Phoenix Manufacturing Co.

W. Wendell Drummond for the past fourteen years engaged in basic and applied research with the Owens-Corning Fiberglas Corp., has accepted a position with the Bjorksten Research Laboratories, Inc.

Robert LePage has been appointed to supervisor of the process engineering section, Abrasives Laboratory, Minnesota Mining & Manufacturing Co.

Howard M. Fitch, general manager of the Herman Nelson Div., has been elected vice president, American Air Filter Co., Inc.

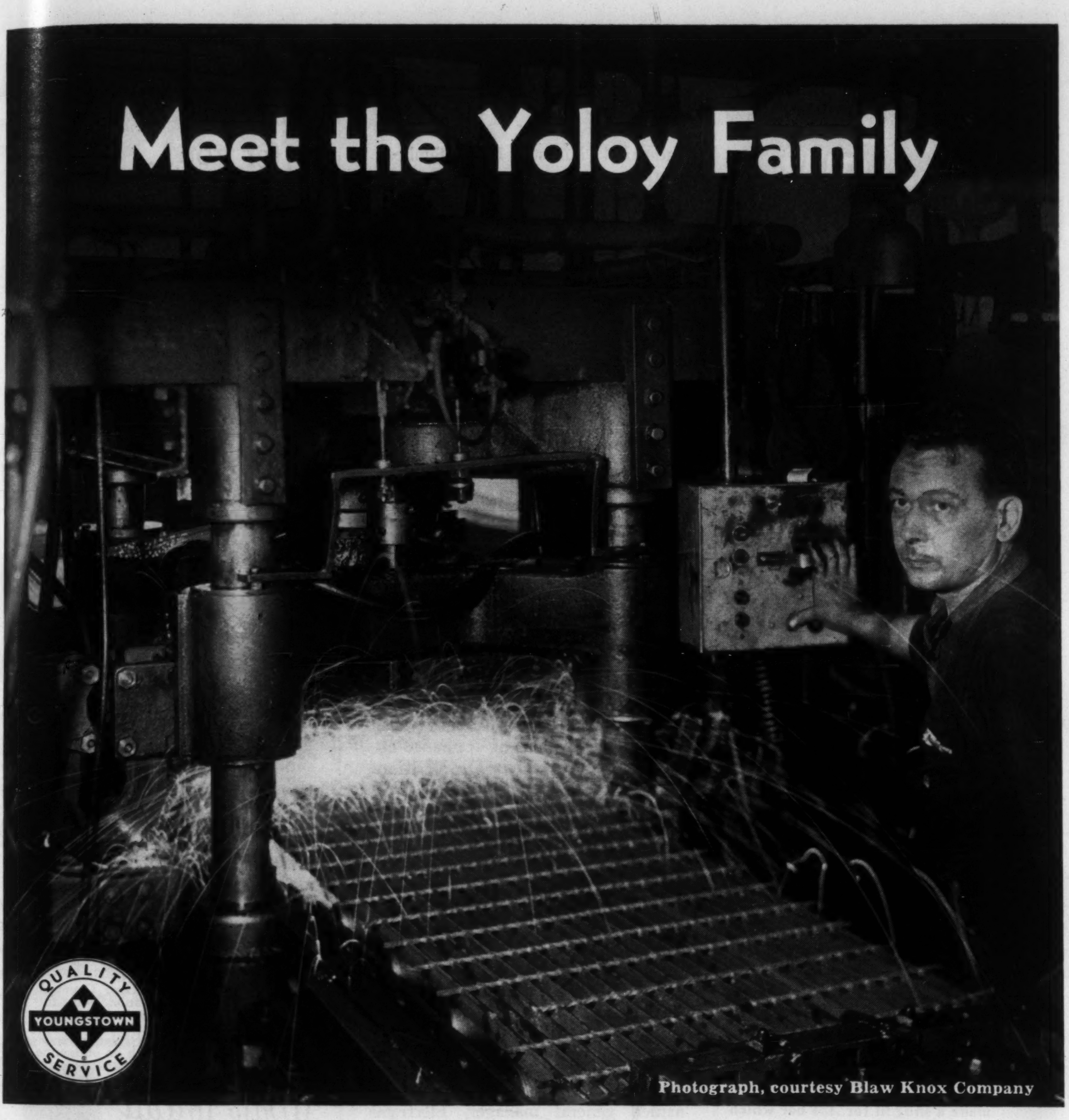
Joseph Schneider has been named director of engineering, Thomas Manufacturing Co.

E. W. Glasenapp has been named general manager, Resistor Dept., Victoreen Instrument Co.

George M. Bryant, formerly with the Textile Research Institute, has joined the Research and Development Dept., Carbide and Carbon Chemicals Corp. Other new members include: **Edward G. Caflisch, Alex E. Brodhag, Donald G. Crosby, Donald L. Heywood** and **Andrew Turner.**

D. H. Gardner has been appointed division general manager,

Meet the Yoloy Family



Photograph, courtesy Blaw Knox Company

●The Yoloy Family of steels are available to fabricators and users who require a steel that's high in resistance to corrosion, shock, vibration and is easy to fabricate and weld. The illustration shows fabrication of "Electro-forged"* grating, using Yoloy E steels, where long life and safety require superior properties. Phone or write our nearest District Sales Office for further information.

*Registered—Blaw Knox Company

Youngstown

YOLOY *(Nickel-Copper)* Low Alloy High Strength Steel
YOLOY E *(Nickel-Chrome-Copper)* Low Alloy High Strength Steel
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SAND-CASTING
FAILED

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INVESTMENT CASTINGS IN ANY CASTABLE ALLOY EXCEPT MAGNESIUM.

Weld Pocket for Lamp Industry

Originally die-cast of Aluminum, this vital part failed because of lack of strength. Sand-casting in Bronze was equally unsatisfactory because shape of part made necessary machining difficult and costly.

When EPCO "know-how" was utilized, the part was investment cast in high tensile Brass . . . machining was eliminated and a stronger, better product was the result.

1/8" slot cast to .125+.002 inches to make a snug fit for .124 bar which passes full length of 4" long slot.

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news of | ENGINEERS

Industrial Furnace Div., Sunbeam Corp.

John W. Spoor has been appointed to the newly-created post of assistant division manager, Welding Products Div., A. O. Smith Corp.

Irving D. Press, chief engineer, Resistoflex Corp., has been made a vice president of the company.

D. J. O'Conor has been named chairman of the board, The Formica Co., and **D. J. O'Conor, Jr.** was elected to follow his father as president.

M. W. Zolton has been named general manager in charge of manufacturing and engineering facilities, York-Gillespie Manufacturing Co.

J. F. Schirtzinger, former Convair engineering executive, has been appointed president and general manager of Consolidated Tool & Products Co.

Dr. Lawrence A. Philipp, vice president in charge of engineering, Nash-Kelvinator Corp., has been made vice president of appliance engineering and research. **Dr. William Mikulas** has been appointed chief engineer, and as head of the Kelvinator engineering department, he will be responsible for all current product engineering and all immediate product development engineering. Dr. Philipp will head the long-range product development and research in addition to acting as consultant on appliance engineering for Nash-Kelvinator, including all divisions and subsidiaries, here and abroad.

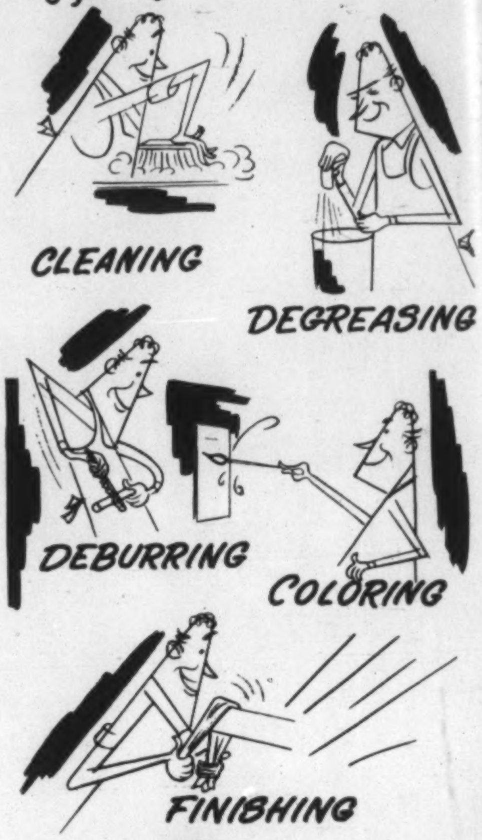
H. M. Campbell has been appointed general manager, Metals Div., and **R. A. St. Clair** has been named general manager, Electrical Div., Olin Industries, Inc.

Clyde Maddox has been named general manager, Industrial Plastics Service and Supply Co.

Paul E. Grigg, a former naval lieutenant commander, will join the staff of Armour Research Foundation, Illinois Institute of Technology as a full ceramic engineer. **Mitchell Sabanas,** a former designer with the Taylor Forge and Pipe Works, has been named a full design engineer at Armour Research Foundation.

Warren C. Hutchins has been named manager of product planning for the Meter and Instrument Dept., General Electric Co. Mr. Hutchins has served as manager of the com-

LORCO barrel finishing compounds offer you...



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LORCO Compounds give you a much wider range of application within a specified family of metals. This enables you far finer finishing results at greatly reduced time cycles.

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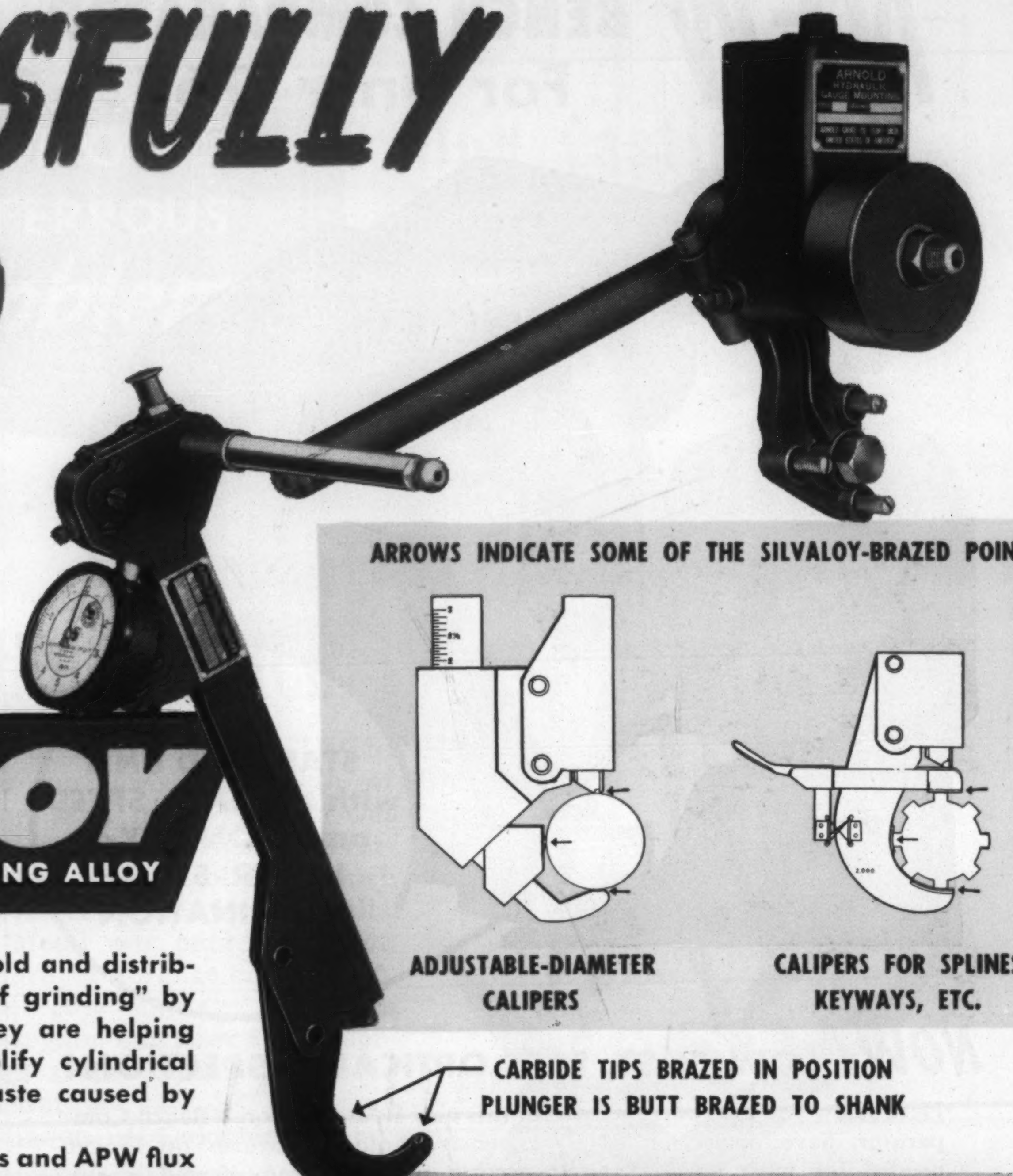

ARROWS INDICATE SOME OF THE SILVALOY-BRAZED POINTS

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Continuous grinding gages made by Arnold and distributed by Federal "take the gamble out of grinding" by automatically controlling dimensions. They are helping many manufacturers to speed and simplify cylindrical grinding operations and to eliminate waste caused by undersize rejects and oversize regrinds.

Silvaloy Low Temperature Brazing Alloys and APW flux are used in the manufacture of these gages, to be certain of strongest possible construction and trouble-free performance. Some of the Silvaloy-brazed points are shown here.

Low Temperature Silvaloy Brazing is helping to speed production, lower costs and improve results for manufacturers in many fields. Call the Silvaloy Distributor in your area for information—or ask him for technical assistance. A Silvaloy Technical Engineer will be sent to your plant, at once, without cost or obligation to you. ★ ★ ★ ★

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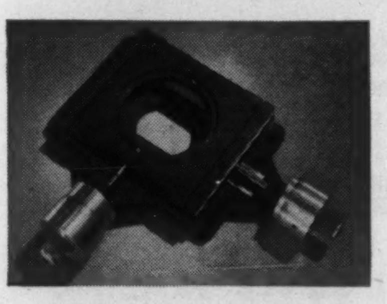

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news of ENGINEERS

pany's Special Products Section at Schenectady for the past 13 years.

Robert T. Frisbie, president, The New Britain Machine Co., has been made chairman of executive committee of the board. Other promotions were announced: **Ralph S. Howe,** executive vice president, will become president; **Julian C. Pease,** a vice president, will become executive vice president and continue as general manager of the New Britain-Gridley Machine Div. of the Company; **Clarence E. Bachman,** general manager of the Precision Products Div., will become a vice president in charge of the Products Div.; **George G. Wilcox,** manager of the Hand Tool Div., will become a vice president in charge of the Hand Tool Div.

Dr. H. J. Osterhof, director of research for The Goodyear Tire & Rubber Co., has been appointed a member of the Materials Advisory Board.

R. F. Allen has been elected a vice president of H. K. Porter Co. and will be in charge of its Buffalo Steel Div.

Don Watkins has joined Continental Foundry & Machine Co. as a vice president.

Hugh T. Price, Jr. was made factory manager of Norton Co.'s Grinding Machine Div. **Roland T. Nelson** replaces Mr. Price as production manager, while **Oscar A. Erickson** takes over Mr. Nelson's job as planning engineer.

Edward H. Wheeler, formerly chief engineer at Standard Pressed Steel Co., has been made manager of the Forging Div. Succeeding Mr. Wheeler is **John M. Sherman,** who was manager of quality control.

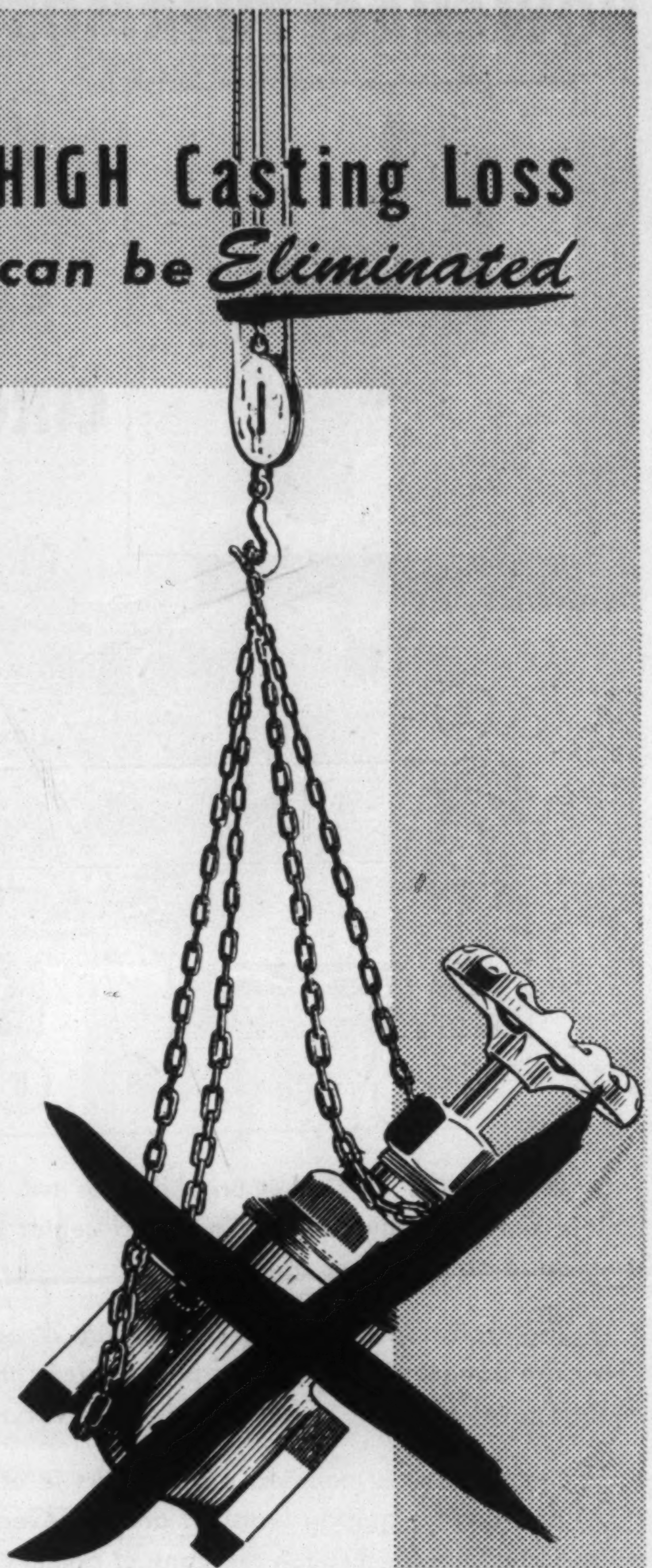
John Lachmann has been appointed executive technical director of Chester Cable Corp. Mr. Lachmann has been employed in the technical department of E. I. du Pont de Nemours & Co. and is known for his specialized work with nylon and polyethylene.

Emil Gairing, founder and former president of the Gairing Tool Co., has joined the Waukesha Tool Co. as a director and executive vice president.

George H. Reed, has been put in charge of American Hard Rubber Co.'s new Chemical Equipment and Plastics Div. The new division com-

THERE IS A SOLUTION TO YOUR NONFERROUS *Foundry Problems...*

HIGH Casting Loss can be *Eliminated*



When you call upon LAVIN'S ENGINEERING SERVICE

The following are some of the causes of LOSING CASTINGS: 1. Permeability of molding sand is too low. 2. Strength of Molding Sand is too low. 3. Molding sand is too wet. 4. Gas holes from a core buckle. 5. Gas holes around cores. 6. Overheating and soaking metal. 7. A porous horizontal line which leaks. 8. Dirty ladles. 9. Dross inclusions embedded in side walls. 10. Cooling casting too rapidly. 11. Metal was poured too hot. 12. Using the swab too freely. 13. Improper furnace combustion. 14. Soft mold ramming. 15. Improper core making. 16. Steam holes from paste in cores. 17. Proper gate but riser ill-proportioned. 18. Undried ladles. 19. Holes from parting and mold cracks. 20. Watch your charcoal. 21. Improper gate. 22. Poor core mixtures. 23. No choke in sprue or runner. 24. Cold Metal.

While we have listed the most common causes for losing castings, the making of each particular casting must be considered as an individual problem.

Lavin's metallurgical staff is always ready to assist the foundryman in finding the solution of any routine or special casting problem. Our chemical and research laboratories are available to you at no cost or obligation.

Next time call upon LAVIN'S engineering service
"The Foundryman's Problems Are Our Problems"

FREE: Write for your copy of the 20-page Lavingot technical Journal Vol. 10. No. 1 & 2 Containing, Specifications . . . test bar designs Nonferrous Ingot & Casting Alloys in chart form.

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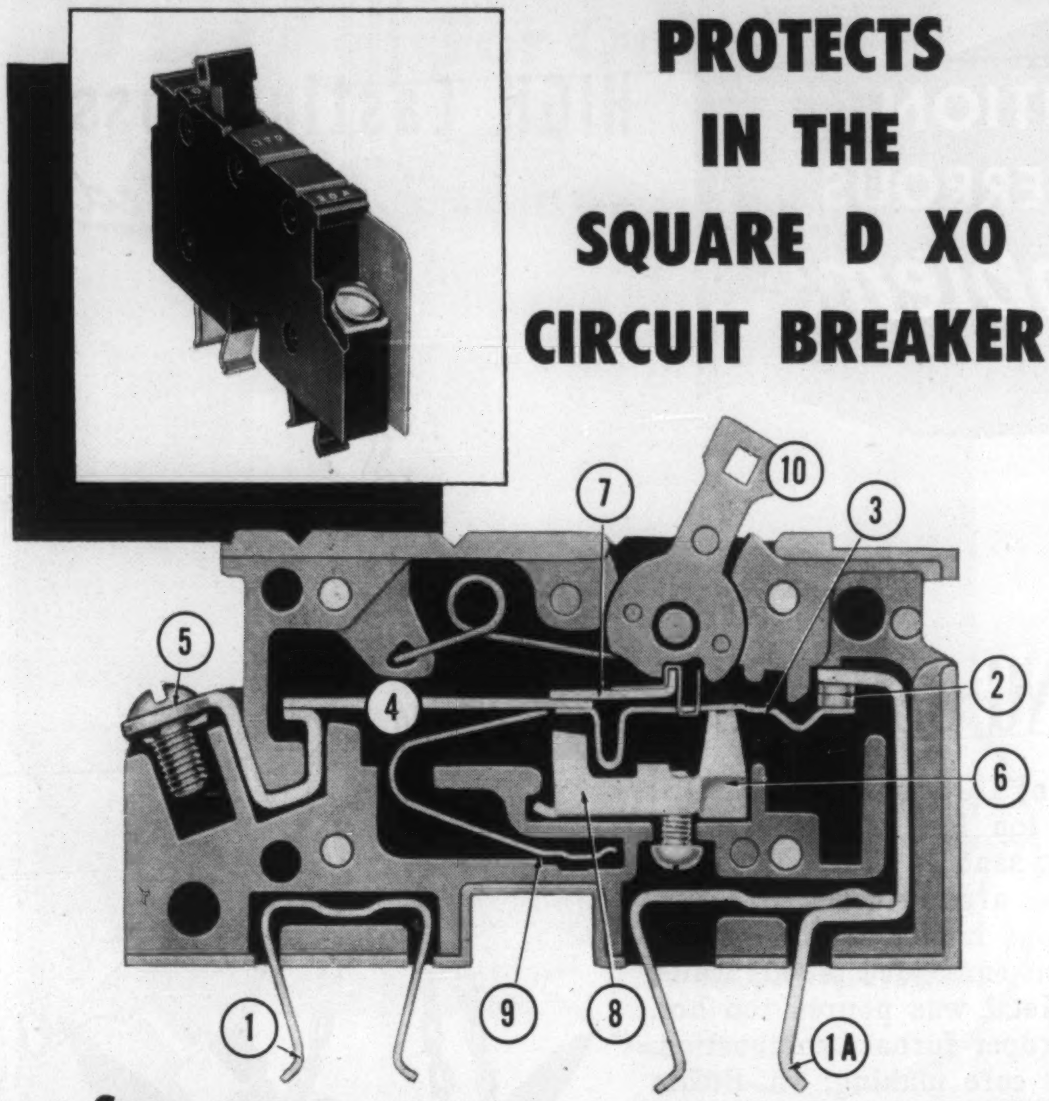
HOW CHACE THERMOSTATIC BIMETAL PROTECTS IN THE SQUARE D XO CIRCUIT BREAKER



Square D's XO Circuit Breaker uses two thermostatic bimetal elements to attain simplicity and safety. This load center device provides easy installation and adaptability to changing condition.

The typical circuit breaker once had 27 operating parts; a recent one had five. The Square D XO unit has but three. Its thermal-magnetic-spring restricted system gives positive, quick action under varying load conditions.

The breaker is mounted on bus bars in enclosures by spring clips (1) and (1A) and can be quickly installed and removed. Current flows from the bus bar to spring clip (1A), through the contact points (2) to the blade (3), then through the thermostatic bimetal element (4) to the terminal (5).

As the thermostatic bimetal element (4) becomes heated by overload, it deflects downward but movement is restricted temporarily by the jaws of spring latch (6), through which it must pass. A heavy overload increases magnetism in armature (7) which is attracted to yoke (8) giving added force to breaking action. The Chace Thermostatic Bimetal element (9) compensates for ambient temperature in the installation. Spring loaded handle (10) moves to left to signal opening of circuit and locks breaker contacts in open position.

Leading manufacturers of products responsive to changes in temperature take advantage of the consulting service we offer. Before you proceed with that new design write for our new 36 page booklet, "Successful Applications of Chace Thermostatic Bimetal." Then, remember, Chace supplies thermostatic bimetal in 29 types, in strip, random lengths or completely fabricated elements of your design.

IT BENDS WITH THE HEAT
W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

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prises the company's Chemical Equipment and Plastics Divisions which have been combined to form one operating unit.

Walter E. Schroeder has been appointed chief engineer of The Colonial Iron Works.

Dr. Hans H. Bleich, professor of Civil Engineering at Columbia University, has been appointed technical director of the Institute of Air Flight Structures. Appointed to assist Dr. Bleich were **Professors Alfred M. Freudenthal, Bruno A. Boley** and **Lee Arnold,** all of the Department of Civil Engineering. The Institute will serve as a national educational and research center for the study of air flight structures, particularly in the supersonic range of jet and rocket-powered aircraft and guided missiles.

William E. Julian has been made general manager, Midwest Precision Castings Co.

P. R. Grossman has been appointed chief research engineer at the Research and Development Center, Babcock & Wilcox Co. **G. A. Watts** has been named as superintendent of products section at the Research and Development Center.

J. J. MacFarland has been promoted to the newly created post of assistant to the general manager of the Plastics Div., Celanese Corp. of America.

William P. Drake has been named president of the new Industrial Chemicals Div., Pennsylvania Salt Manufacturing Co.

David A. Griffith has been named general manager of Allis-Chalmers Pittsburgh Works.

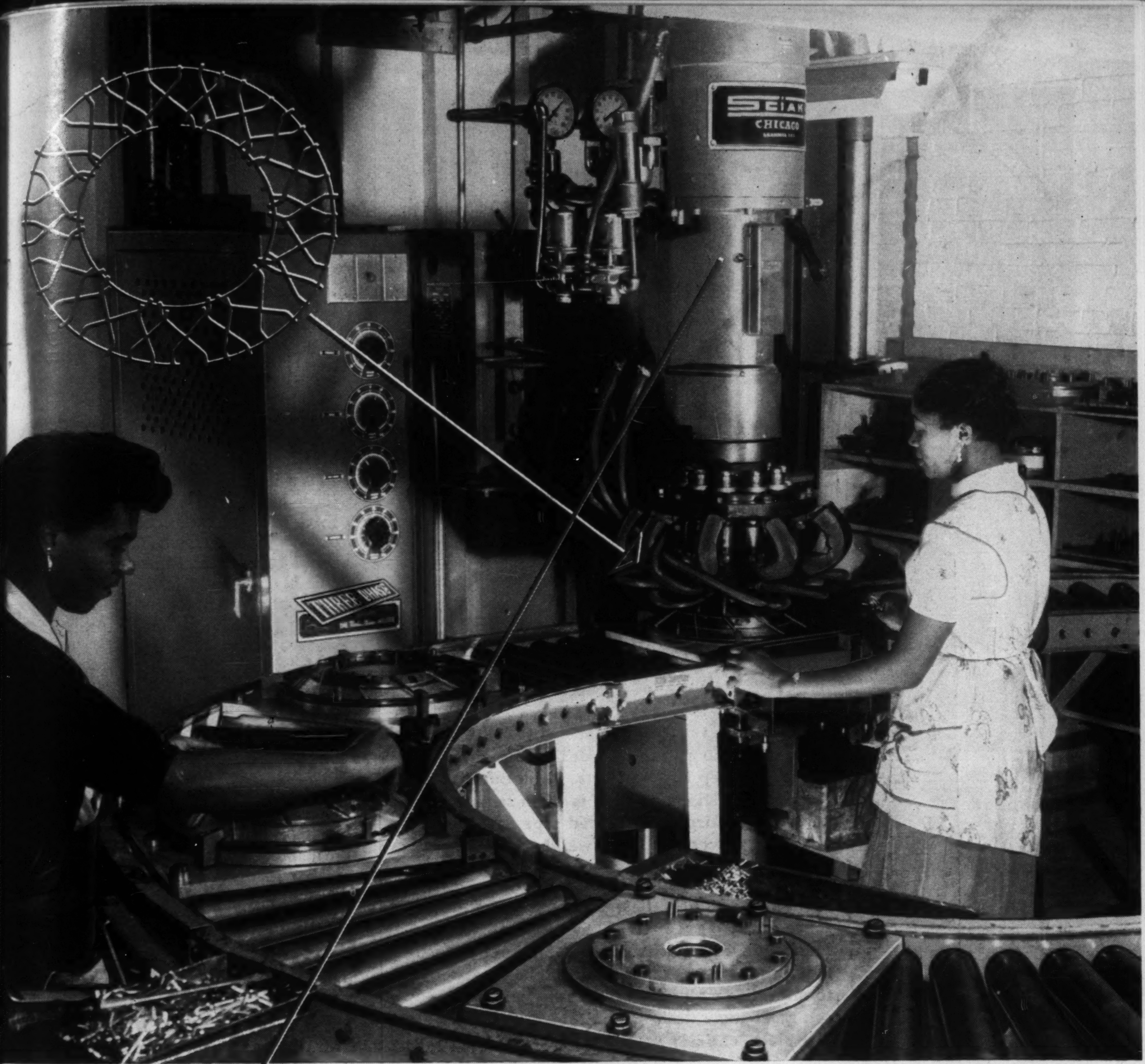
David D. Hecht has been promoted to the post of manager of the Product Development Dept., Chemical Div., Celanese Corp. of America.

Dr. Alex Katona has joined the Research and Development Dept., Hooker Electrochemical Co.

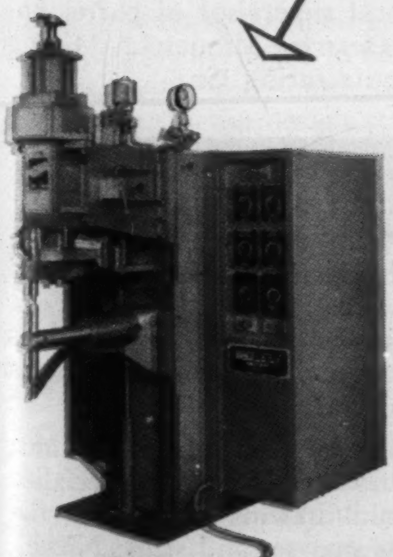
Alfred H. Pope, formerly a member of Pennsylvania Salt Manufacturing Co.'s technical department staff, has been named product supervisor for Pennsalt's metal cleaners.

H. F. Devens has been appointed assistant to the general manager, Metals, Div., Olin Industries, Inc.

E. J. Tribble, former works manager of Worthington Corp.'s Harrison, N. J., Works, has been named



40 Spokes of .430 Stainless Resistance Welded to 2 Rings in Simulated Wire Wheels



CASCO PRODUCT'S (Bridgeport, Conn.) design of their complex, 42 piece wire wheel assembly presented serious problems of high production, allowable tolerances for positive fit, and cost of fabrication. Sciaky patented Three-Phase resistance welding provided most suitable answers to all requirements.

Two standard Sciaky welders complete the entire assembly in only four operations at a production rate of over a thousand per day. No skilled workers are required to produce assemblies that satisfy rigid inspection for alignment and set-down of welds. Sciaky Three-Phase produces smooth fillet welds eliminating special metal finishing. For complete details, write for R.W.A.W., Vol. 3, Number 9.

Resistance welding of Casco wire wheels is another fine example of Sciaky's basic thinking—welders designed to do *more useful work* at *lowest operating cost* with *maximum reliability*.

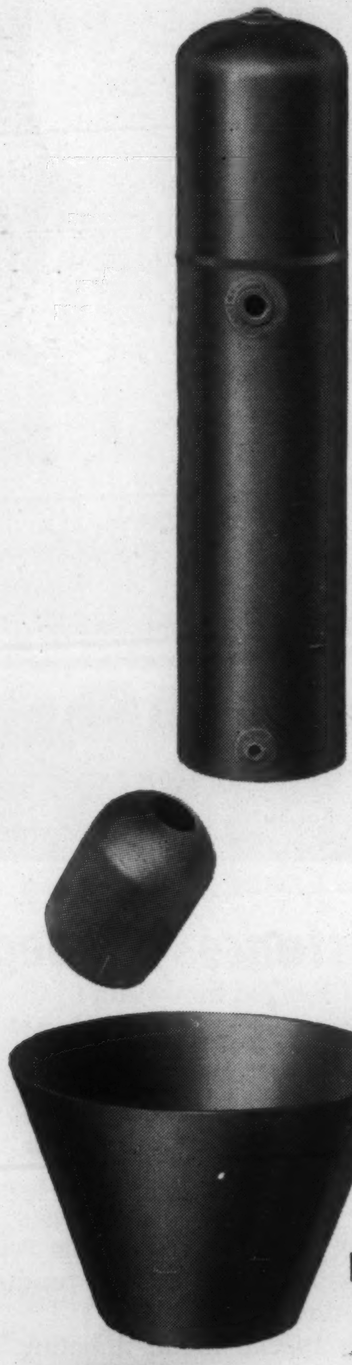
Largest Manufacturers of Electric Resistance Welding Machines in the World

SCIAKY

4929 West 67th Street, Chicago 38, Illinois

For more information, turn to Reader Service Card, Circle No. 373

when your
customers
ask about . . .



product strength–

Cite the facts on the extra strength you have built into your product by designing with Hackney Deep Drawn Parts. Point out that a deep drawn shape or shell is often stronger than a cast, forged or welded pipe part which it replaces, even though it weighs far less.

That's the way hundreds of other manufacturers have designed stronger and more durable products. They discovered that Hackney Deep Drawn Parts can be made from high strength steel—can be heat-treated to minimize welding and forming stresses — can meet some design requirements as a one-piece, entirely seamless part.

In addition to extra strength and extra long life, Hackney Deep Drawn Shapes and Shells often contribute other product improvements, including:

Closer tolerances
Vibration resistance
Streamlined appearance
Faster assembly—Lower cost
Sizes from one quart to 150 gallons
Write today for additional information.

PRESSED STEEL TANK COMPANY
Manufacturer of Hackney Products
1442 South 66th St., Milwaukee 14
52 Vanderbilt Avenue, Room 2019, New York 17
241 Hanna Bldg., Cleveland 15
936 W. Peachtree St., N.W., Room 111, Atlanta 3
208 S. LaSalle St., Room 788, Chicago 4
559 Roosevelt Bldg., Los Angeles 17
18 W. 43rd St., Room 11, Kansas City 11, Mo.

Hackney
MILWAUKEE

DOWNINGTOWN IRON WORKS

DOWNINGTOWN IRON WORKS, INC., DIVISION
136 Wallace Ave., Downingtown, Pennsylvania

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

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news of | ENGINEERS

assistant vice president in charge of manufacturing with headquarters at the Harrison Works; **A. M. Tullo,** former works manager of the company's Wellsville, N. Y., Works, will assume Mr. Tribble's former position, and **L. E. Hammer,** former Wellsville assistant works manager, will take over Mr. Tullo's former post.

Sam Laud has been elected vice chairman of the board of General American Transportation Co. Other officers of the company elected at the recent board meeting include: **William J. Stebler** as president, **Frank E. Selz** as vice president in charge of the Plastics Div., **Herman Altschul** as vice president in charge of freight car sales, **James S. Frey** as vice president in charge of manufacturing and **Spencer D. Moseley** as assistant to the president.

H. A. Denny has been appointed vice president and assistant general manager of the Engineering and Construction Div., Koppers Co., Inc. Also named to new posts were **A. B. Fisher, Jr.,** a divisional vice president who will be general superintendent of construction, **George P. Wilson** who will be production manager, and **Richard W. Vollmer** who will assume the duties of manager of the Chemical and Gas Dept. of the Engineering and Construction Div.

Nelson C. George, assistant chief metallurgist at Gary Sheet and Tin Mill, United States Steel Corp., has been promoted to chief metallurgist. Mr. George succeeds **John A. Eckel** who has been promoted to assistant to the general superintendent at U.S. Steel's Fairless Works.

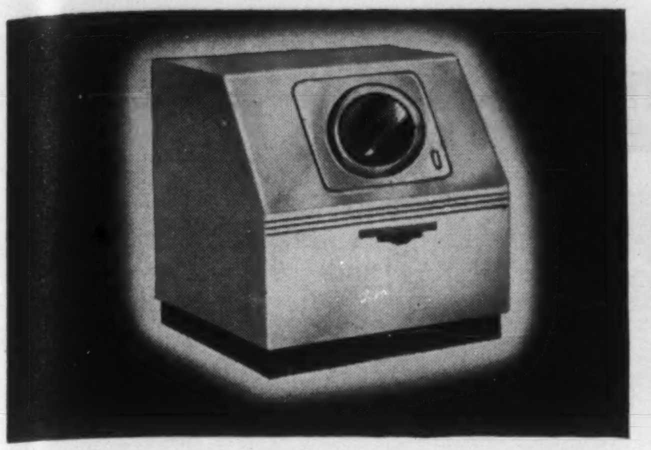
John Glasrud has been appointed as technical supervisor of barrel finishing research, Minnesota Mining and Manufacturing Co.

news of | COMPANIES

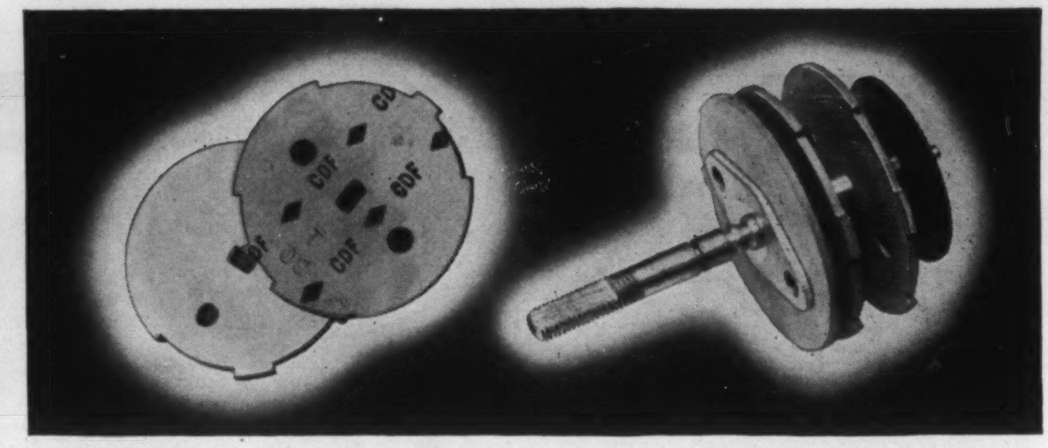
Zenith Plastics Co. has announced the consolidation of all its aircraft engineering and fabrication facilities into a new division, to be known as Zenith Aircraft.

Techalloy Co., Inc., Rahns, Penna., has been formed to specialize in the cold drawing of wire in the following analyses and sizes: Nickel, Monel, Inconel 1/2 to .002 in., Techalloy Stainless Steels 1/4 to .002 in.

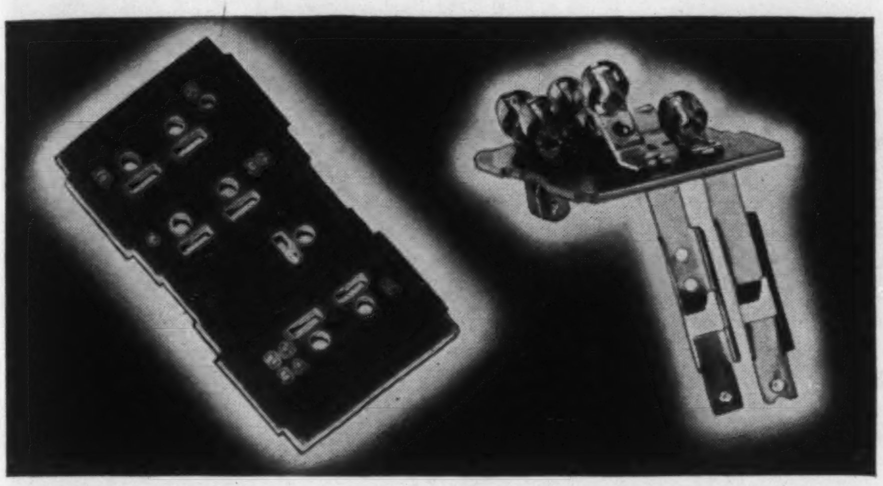
(Continued on page 206)



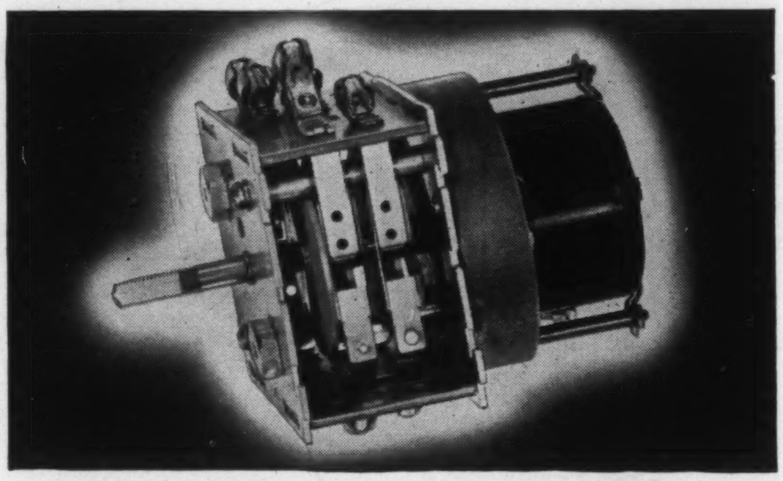
What makes the miracle of automatic washdays? What gadget turns water on and off; starts spinners, agitators, fans; regulates heat . . . all on a precise timing schedule? Chances are it's a P. R. Mallory timer switch.



Special paper-base Dilecto laminated phenolic cams are the heart of the switch. If the corners are not sharp, if tolerances are not held, if the laminated plastic fails, the timing schedule would go haywire. But it doesn't happen with Dilecto cams *fabricated by C-D-F,* now definitely identified for performance comparison.



C-D-F also supplies these Dilecto insulating side boards. Dilecto Grade X-13 was chosen for its ability to withstand severe riveting and staking impact, for its sturdiness in holding up under the strain of plugs being inserted and removed from terminals mounted on the board.



Look inside the smart, small, tough Mallory timer switch. The shaft revolves; with the switch operated by a manual clock which is wound or set whenever the switch is turned over to complete the entire cycle. *Switch accuracy depends entirely on the degree of accuracy in which the cam is manufactured.*

C-D-F and DILECTO® LAMINATED PLASTIC helped Mallory

improve design . . . simplify purchasing . . . speed production

Two C-D-F Dilecto laminated plastic parts play small but vital roles inside P. R. Mallory's timer switches used to control the washing, drying, rinsing cycles.

Most important, the timing cams must be precisely fabricated to odd, notched shapes, with very close dimensional tolerances. In the design stage, it was first thought that there was no practical way to obtain the desired pieces.

But engineering-supplier teamwork always pays off. Good basic design . . . a quality material from an alert, interested fabricator . . . selective purchasing resulted in a solution.

C-D-F WORKS WITH DESIGNERS

A father and son team, in Mallory's Switch Division, Arthur and Harry Hall, began 15 years ago to make this timer switch. Cam material after material was tested . . . none worked satisfactorily. C-D-F sales engineer Robert Tappan was called in. He says, "After 18 months, the design was adaptable to Dilecto laminated plastic. The first cam did not work, but showed promise. Looking back, it was a crude punching compared to the ones now furnished by the C-D-F Valparaiso plant."

A BIG, RELIABLE SOURCE

Mallory makes thousands of timer switches, naturally has several suppliers for laminated plastic insulation. But C-D-F keeps working hard to further improve the product: Special tools have been designed to increase the accuracy of C-D-F cams, to provide Mallory with *lower rejection* rates. Resin-penetrating and laminating techniques have improved Dilecto grades. Inspection and quality control have been modernized.

When you have a problem in laminated plastics, think of improved, Dilecto and C-D-F. Send us your print for technical advice and quotation. Write for free test samples. The C-D-F catalog is in Sweet's Design File and the IRE Directory. Best of all, call your C-D-F sales engineer . . . He's a good man to know!

CDF *Continental-Diamond Fibre*

CONTINENTAL-DIAMOND FIBRE COMPANY
NEWARK 25, DELAWARE

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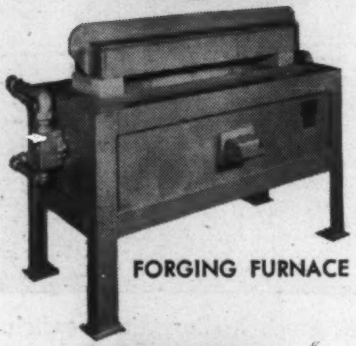
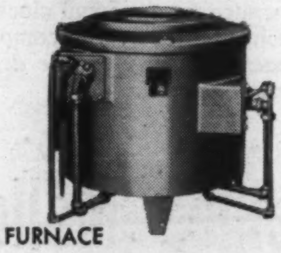
get the best out of your tool steel through

PROPER DRESSING

FORGING HAMMER



FORGING FURNACE



POT FURNACE

QUENCH TANK

TEMPERING FURNACE

TOOL GRINDER

Here is a "Package" that will get rid of a costly and annoying problem . . . In fact, it will save up to 60% of costs for cutting and chipping tools . . . the best life is gotten out of today's steels through proper dressing . . . proper steel, properly treated, will reduce costs substantially. Now, at your own convenience, you can dress as many tools as are needed, and keep close control of your tool inventory.

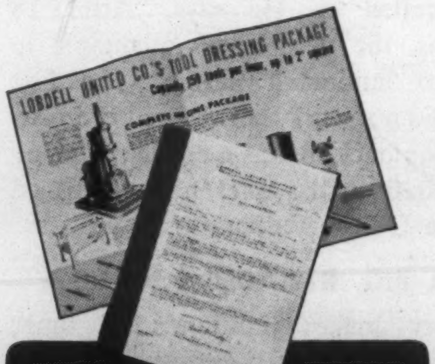
The complete "Tool Dressing Package", entirely engineered by LOBDELL UNITED CO., (subsidiary of United Engineering and Foundry Co.) . . . includes all of the Forging, Heat Treating and Dressing Equipment . . . plus, the practical methods needed . . . and this "Package" not only reduces inventory costs, but it can do this at *low initial cost*, recoverable nominally in one year . . . without special metallurgical control.

The "versatile" NAZEL Electro-Pneumatic Forging Hammer is the LOBDELL UNITED CO. product . . . For the additional equipment presented within this "Package", LOBDELL is joined by a group of the most reputable leaders in their fields:

Heating Equipment by Eclipse Fuel Engineering Company

Tool Grinding Equipment by Black and Decker Company

Accessory Tools and Tool Steels by Bedford Tool and Forge Company



A copy of LOBDELL's new "Tool Dressing Package" Bulletin will give you further details.

LOBDELL UNITED COMPANY

1836-1954 WILMINGTON 99, DELAWARE

A SUBSIDIARY OF UNITED ENGINEERING AND FOUNDRY COMPANY

For more information, turn to Reader Service Card, Circle No. 436

news of COMPANIES

Pastushin Aviation Corp. has enlarged its administrative and engineering facilities. Additional heat treating and welding facilities are expected to increase production capacity while a 4000 sq ft building has been added to the Engineering Dept. for intensive research in plastics.

Aviation Devolpment Inc. has announced that its new $75,000 building is nearing completion. Construction of the new building at 210 S. Victory Blvd., Burbank, Calif., makes the second expansion in five years for the company.

H & B American Machine Co. and **Susquehanna Mills, Inc.** have announced merger plans to form the H & B American Machine Co., Inc. Victor Nemeroff, president, H & B, was elected president of the surviving corporation. The merger, however, is subject to the formal approval of the creditors of Susquehanna.

Pennsylvania Salt Manufacturing Co. will establish two new operating divisions to be known as the Industrial Chemicals and Chemical Specialties Divisions. The new components will function as complete operating units responsible for both the manufacture and sale of their respective products.

National Vulcanized Fibre Co. is planning a modern research laboratory to be housed in what is currently a large stone warehouse at Yorklyn, Del.

General Electric Co. recently broke ground for a new plant in Waynesboro, Va., which will manufacture electronic controls for industrial and aviation use. Expected to be in full operation some time next year, the plant will employ about 550 people.

Polymer Industries, Inc. recently opened a new plant in Springdale, Conn., which is expected to increase the firm's manufacture of industrial adhesives and textile chemicals by fifty per cent. The new 25,000 sq ft facilities consolidate Polymer Industries' former operation in Astoria, L. I. and Brooklyn, N. Y.

Fairbanks, Morse & Co. has formed a new Electronics Div. which will be responsible for research, development, application engineering and manufacture of electronic devices and apparatus used in conjunction with various company products.

(Continued on page 208)

an ACCO product

Wilson "Rockwell"* Hardness Testers

New Motorized
WILSON "ROCKWELL"*
Hardness Tester with
SET-O-MATIC* Gauge
SET-O-MATIC
WILSON
ROCKWELL
WILSON
Y MODEL
MOTOR-OPERATED

Eliminates Operations... Increases Tests per Hour

SET-O-MATIC*

DIAL GAUGE

• Eliminates human error. Operator merely applies minor load and taps depressor bar. No setting of dial to zero.

OTHER FEATURES

- **Major load applied under dash pot control**
- **Major load removed by motor**
- **Illuminated Dial Gauge**
- **Illuminated Penetrator**

• All you have to do with the Model Y WILSON "ROCKWELL" Motorized Hardness Tester is apply the minor load and tap the major load depressor bar. The machine does everything else automatically. The cycle of Major Load operation may be less than 2 seconds.

The Model Y WILSON "ROCKWELL" Motorized Hardness Tester permits great savings in time which will reduce your hardness testing costs. Yet there is no sacrifice of Wilson's high standard of accuracy.

The utter simplicity of setting the SET-O-MATIC* dial gauge eliminates human error. The operator does not have to set the dial. The large pointer is automatically brought to "SET" position when the minor load is applied.

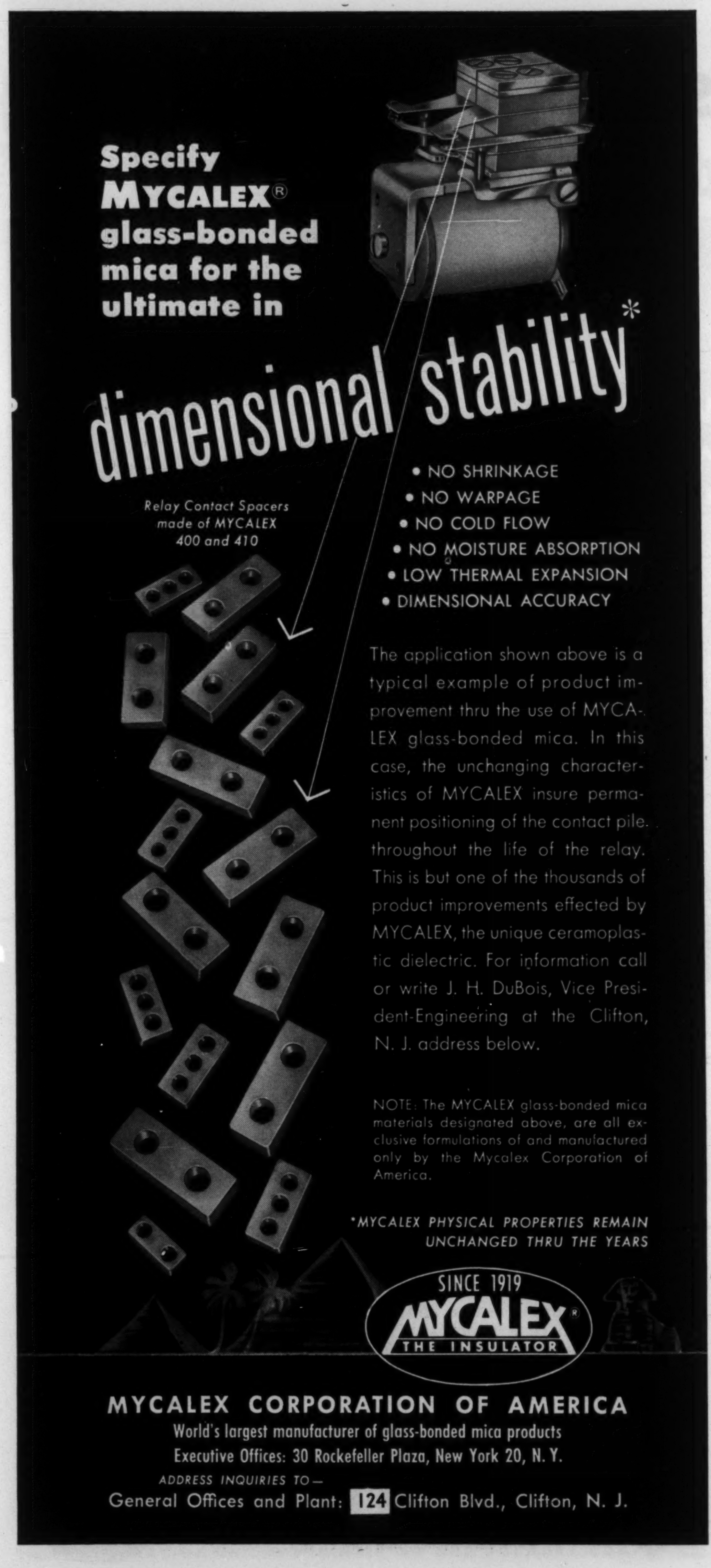
The Model Y Motorized WILSON "ROCKWELL" Hardness Tester is in production and orders are being accepted for early delivery. Write today for descriptive literature and prices on the Model Y or other WILSON "ROCKWELL" hardness testers.

** Trade Marks*

ACCO
TRADE MARK
Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE
230-E Park Avenue, New York 17, N. Y.

plus BRALES and TUKON

For more information, turn to Reader Service Card, Circle No. 390



Specify **MYCALEX**® glass-bonded mica for the ultimate in

dimensional stability*

Relay Contact Spacers made of MYCALEX 400 and 410

- NO SHRINKAGE
- NO WARPAGE
- NO COLD FLOW
- NO MOISTURE ABSORPTION
- LOW THERMAL EXPANSION
- DIMENSIONAL ACCURACY

The application shown above is a typical example of product improvement thru the use of MYCALEX glass-bonded mica. In this case, the unchanging characteristics of MYCALEX insure permanent positioning of the contact pile throughout the life of the relay. This is but one of the thousands of product improvements effected by MYCALEX, the unique ceramoplastic dielectric. For information call or write J. H. DuBois, Vice President-Engineering at the Clifton, N. J. address below.

NOTE: The MYCALEX glass-bonded mica materials designated above, are all exclusive formulations of and manufactured only by the Mycalex Corporation of America.

*MYCALEX PHYSICAL PROPERTIES REMAIN UNCHANGED THRU THE YEARS

SINCE 1919
MYCALEX®
THE INSULATOR

MYCALEX CORPORATION OF AMERICA
World's largest manufacturer of glass-bonded mica products
Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.
ADDRESS INQUIRIES TO—
General Offices and Plant: 124 Clifton Blvd., Clifton, N. J.

For more information, turn to Reader Service Card, Circle No. 451

news of | COMPANIES

The General Tire & Rubber Co. has announced that its stockholders have approved the mergers of the **Textileather Corp.** and the **Bolta Corp.** into the General Tire & Rubber Co. The mergers are expected to become effective April 30 with the filing of papers with the State of Ohio.

Revere Copper and Brass Inc. has purchased a plant in Lockport, Ill. for the production of Lockseam tube, rolled moldings and shapes, presently made in the company's Chicago manufacturing plant.

Robertshaw-Fulton Controls Co. is expanding its production facilities with the opening of a new plant at Indiana, Penna.

General Electric Co.'s new $25,000,000 plant at Rome, Ga., said to be the most modern power transformer plant in existence, was recently opened.

Hercules Powder Co. has announced a fifty per cent expansion in the production facilities for Parlon, chlorinated rubber. Construction of the new unit will begin immediately at the company's plant in Parlin, N. J.

REF Manufacturing Corp. has announced establishment of a new division to be known as Poly-Plastics and devoted to the engineering, development and manufacture of quality reinforced plastics, plastic laminates, and honeycomb structures. Managing the new division will be Ernest W. Fuller, formerly director of staff engineering, American Airlines.

Kasson Die & Motor Corp. is now located at 32-14 Northern Blvd., Long Island City 1, N. Y.

H. I. Thompson Fiber Glass Co. recently purchased a new plastics division. The new division will continue to operate under the name of **Industrial Plastics Co.,** (Division of H. I. Thompson Fiber Glass Co.) 1526 West 166th St., Gardena, Calif. The firm will manufacture a variety of products for industry and consumer use in the field of glass-reinforced plastics. Brandt Goldsworthy has been elected vice president of H. I. Thompson and will head the new division.

Plastic Products Corp. is building a new molding plant designed specifically for the molding of fiber

V.I.P. treatment

You won't find it described in the books on metallurgy. But it's a mighty important factor here at Claymont in supplying you with carbon and alloy steel plates that are tailored to your specialized requirements.

To us it means *Very Important Plates*. It means individualized supervision of your order . . . particular attention to every detail of analysis, processing and inspection—right down the line from top to bottom.

Let us know your requirements—large or small. Our location in the heart of the Delaware Valley gives us complete access to convenient rail, water and highway transportation . . . enables us to efficiently and economically serve your needs.

CF&I

Claymont Steel Products

PRODUCTS OF WICKWIRE SPENCER STEEL DIVISION • THE COLORADO FUEL AND IRON CORPORATION

2283

ABILENE • ALBUQUERQUE • AMARILLO • ATLANTA • BOISE • BOSTON • BUFFALO • BUTTE • CASPER • CHICAGO • DENVER • DETROIT • EL PASO • FT. WORTH HOUSTON • LINCOLN • LOS ANGELES • NEW ORLEANS • NEW YORK • OAKLAND • ODESSA • OKLAHOMA CITY • PHILADELPHIA • PHOENIX • PORTLAND • PUEBLO SALT LAKE CITY • SAN FRANCISCO • SEATTLE • SPOKANE • TULSA • WICHITA • *Canadian Representatives At* • EDMONTON • TORONTO • VANCOUVER • WINNIPEG

OTHER CLAYMONT PRODUCTS

Flanged and Dished Heads • Manhole Fittings and Covers
Stainless Clad Plates • Large Diameter Welded Steel Pipe

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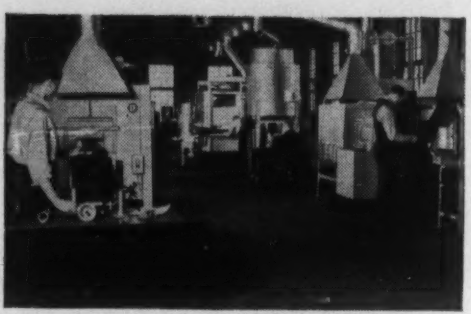
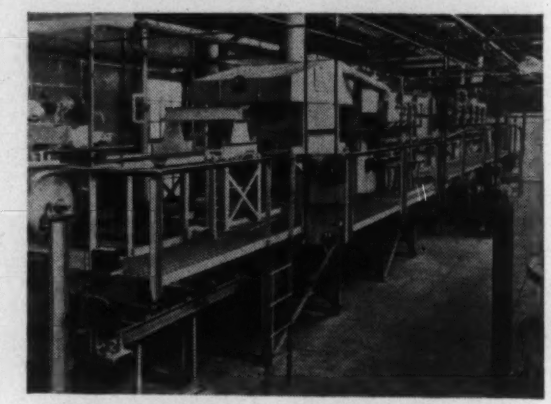
EF
RESEARCH DEPARTMENT
available to
PRODUCERS and PROCESSORS
of metals and metal products



General view of the research department showing several of the continuous and batch type experimental furnaces.

● From our fully equipped research department we can determine accurately—from test runs—the combination of temperature, time cycle, atmosphere and other factors needed to produce the exactly desired result,—assuring—in advance—the efficient performance of EF furnaces **fully up to specification.**

Many large companies have drawn liberally upon this department in developing new products, and new techniques. Our facilities are available to YOU also—for YOUR research or development work, either gratis or for a moderate fee, depending upon the nature of the experiment. We will be glad to schedule time for your technicians, or write today for our 12 page booklet, "Research Facilities". It describes the equipment we can place at your disposal.

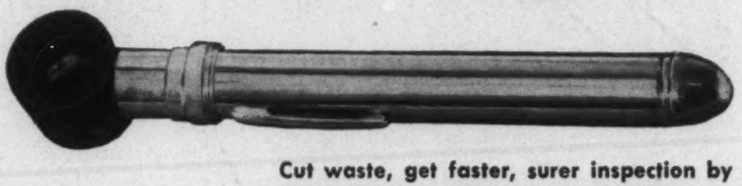


View of combination gas-fired and electric continuous furnace equipped with flame preheating burn-off or oxidizing section and controlled heating, soaking and cooling zones, for producing various surface conditions on strip.

Gas-Fired, Oil-Fired EF ***and Electric Furnaces***
for any Process, Product or Production
THE ELECTRIC FURNACE CO.
WILSON ST. at PENNA. R. R. *Salem - Ohio*
Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada

How to speed production with MAGNIFIERS

New! Illuminated 10x Pocket Magnifier



WRITE for new handbook and catalog, "Industrial Magnifiers—How to Choose and Use Them." Bausch & Lomb Optical Company, 50330 Bausch St., Rochester 2, N. Y.

INDUSTRIAL
Magnifiers
HOW TO CHOOSE AND USE THEM

Cut waste, get faster, surer inspection by fitting the magnifier to the job. This new Bausch & Lomb Illuminated Coddington floods entire viewing field with bright light *through* the lens, permitting quick, accurate on-the-spot inspection, without need for outside lighting. Image quality is excellent! Carry this new magnifier with you always—anywhere $7.50

Another product by Bausch & Lomb—recognized world leader in all things optical

B&L BAUSCH & LOMB *Magnifiers*

For more information, turn to Reader Service Card, Circle No. 495

Continued from page 208

glass reinforced plastics. The new addition will be located in Bedford Heights, a suburb of Cleveland.

news of | SOCIETIES

The **Gray Iron Founders' Society** has announced the appointment of Charles F. Walton, Professor of Metallurgy, Case Institute of Technology, as technical director.

The **American Foundrymen's Society** presented its Wm. H. McFadden Gold Medal to Walter E. Sicha, chief of the Cleveland Research Div., Aluminum Co. of America. The Alcoa scientist was cited in the award "for extensive and valuable work on light metal casting alloys and for outstanding contributions to the Society."

American Society of Tool Engineers has elected Joseph P. Crosby, vice president, LaPointe Machine Tool Co., as its new president. Elected with Mr. Crosby were Dr. H. B. Osborn, Jr., technical director, TOCCO Div., Ohio Crankshaft Co., as first vice president; H. C. McMillen, plant manager, Philco Corp., as second vice president and H. E. Collins, manager, Process Engineering Dept., Hughes Tool Co., as third vice president.

The **Metal Powder Association,** at its recent meeting in Chicago, elected officers for the coming year: Paul E. Weingart, American Metal Co. Ltd., was elected president; William E. Cairnes, president Radio Cores, Inc., a vice president of the Association and head of the Electronic Core Div. was elected Chairman of the board; Robert L. Ziegfeld, secretary-treasurer of the Association, was re-elected; Morris Boorky, The Pressmet Co., was elected head of the Fabricators Div. and vice president of the Association; Paul Weingart was elected head of the Powder Producers Div; Carl Johnson, vice president, The Pressmet Co., and Ralph B. Quelos, general sales manager, Chemicals-Pigments-Metal Div., Glidden Co., were both newly elected directors. The balance of the board consists of George Roberts, Vanadium Alloys Steel Co; Fred Lux, Lux Clock Manufacturing Co; B. T. duPont, Plastics Metals Div., National Radiator Co.; Harrison Stackpole, Stackpole Carbon Co.

(Meetings and Expositions on page 212)

one is always best

...and REX is the standard by which all high speed steels are compared

No matter how keen the competition, there can be only one winner. And the difference between the winner and the runner-up, whether it's golf or making high speed steels, is measured in performance.

Crucible REX® high speed steels have proved their championship qualities under the toughest sort of competition — in actual use in thousands of tool shops throughout the world. But check for yourself. Try a piece of REX high speed steel on your next job. Compare its hardenability, response to heat treatment, its fine tool performance. You won't find another high speed steel to outperform REX.

Ask for REX by name wherever high speed steels are sold. But remember, REX is made *only* by Crucible.

Buy U.S. Savings Bonds

CRUCIBLE first name in special purpose steels

54 *years of* Fine *steelmaking*

TOOL STEELS

RUCIBLE STEEL COMPANY OF AMERICA • TOOL STEEL SALES • SYRACUSE, N. Y.

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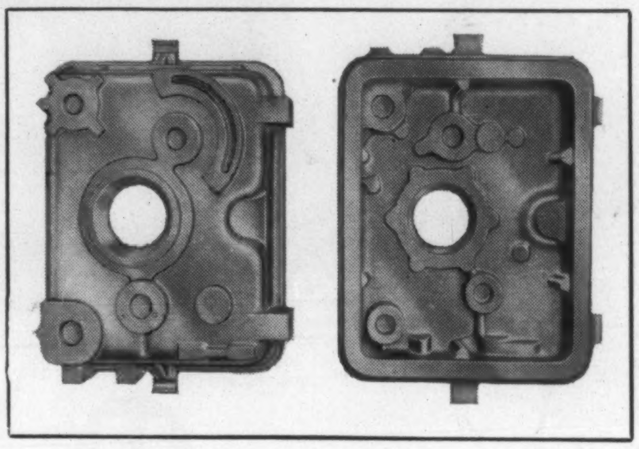

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"WE REQUIRE THE BEST,"

says this user of OPC castings

Fenjohn Underwater Photo & Equipment Co. uses OPC #356 aluminum castings in the production of underwater cameras. "OPC castings are very clean . . . require less machine work . . . particularly pleased with lack of porosity, as the need for our equipment to go 200-250 feet underwater requires the best in this field." When *you* "require the best" in castings, check first with Ohio Precision Castings, Inc.

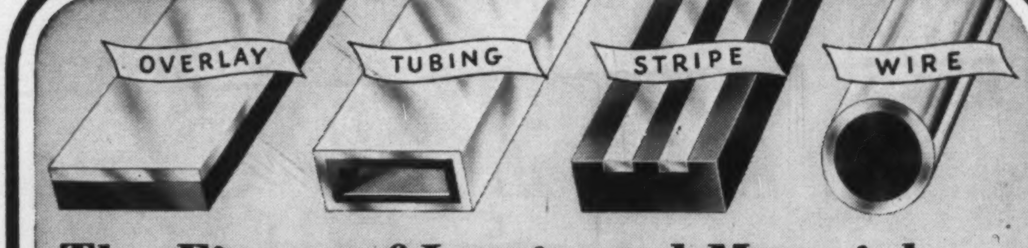
Fenjohn underwater cameras can withstand limited pressure, shock, heat, sterilization and flying debris.

The smooth finish and precise accuracy of this highly detailed OPC casting eliminates hours of costly machining time.

OPC

OHIO PRECISION CASTINGS, INC.
109 Webb Street • • • • DAYTON 3, OHIO
Plaster Mold Castings made from
BRASS • BRONZE • ALUMINUM • BERYLLIUM COPPER

ILLUSTRATED BROCHURE
Write NOW for your copy of new, illustrated brochure giving examples of on-the-job savings made possible with OPC castings.



The Finest of Laminated Materials...

We are providing manufacturers with a complete line of precious metals laminated to non-precious base metals made to their exact specifications within the following limitations:

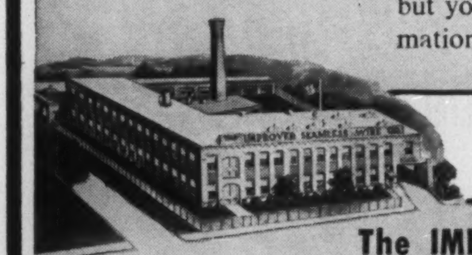
SHEET STOCK: Maximum width—5"
Minimum width—¼".
Thickness—down to .003"

TUBING: Maximum diameter 1" x .050" wall

WIRE: All sizes down to .0045" diameter also squares, rectangular and odd shapes.

In addition to laminated materials we also furnish alloyed gold and silver in sheet, wire or tubing form.

The many varied applications of our materials cannot be listed here, but you are cordially invited to inquire for information regarding your requirements.



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Meetings and Expositions

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting. Pittsburgh. June 20-24, 1954.

INSTITUTE OF THE AERONAUTICAL SCIENCES, summer meeting. Los Angeles. June 21-24, 1954.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer and Pacific general meeting. Los Angeles. June 21-25, 1954.

ALLOY CASTING INSTITUTE, annual meeting. Hot Springs. June 27-29, 1954.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, semi-annual meeting. Swampscott, Mass. June 28-30, 1954.

AMERICAN ELECTROPLATERS' SOCIETY, annual convention. New York. July 12-15, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. Los Angeles. August 16-18, 1954.

WESTERN ELECTRONIC SHOW & CONVENTION, Los Angeles. August 25-27, 1954.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Milwaukee. Sept. 8-10, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national tractor meeting and production forum. Milwaukee. Sept. 13-16, 1954.

INSTRUMENT SOCIETY OF AMERICA, international instrument congress and exposition. Philadelphia. Sept. 13-20, 1954.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Instruments and Regulators Div. and Instrument Society of America exhibit and joint conference. Philadelphia. Sept. 13-24, 1954.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. White Sulphur Springs, W. Va. Sept. 27-28, 1954.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs. Sept. 29-30, 1954.

ELECTROCHEMICAL SOCIETY, fall meeting. Boston. Oct. 3-7, 1954.

NATIONAL ELECTRONICS CONFERENCE, INC., annual meeting. Chicago. Oct. 4-6, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national aeronautics meeting, aircraft production forum and aircraft engineering display. Los Angeles. Oct. 5-9, 1954.

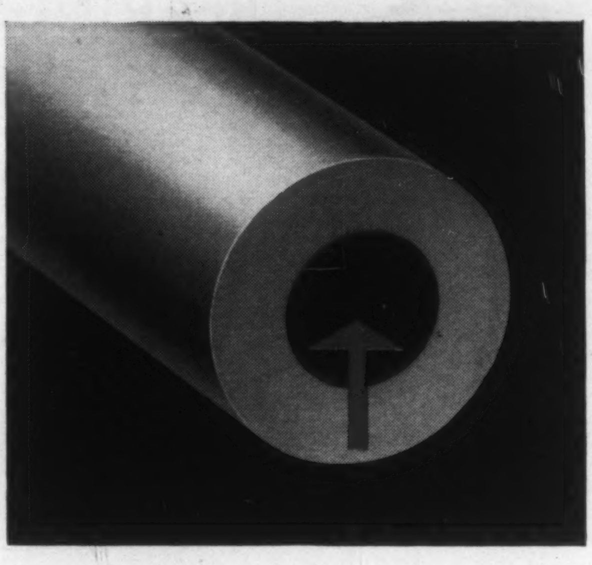
NATIONAL FOUNDRY ASSOCIATION, annual meeting. Chicago. Oct. 6-8, 1954.

AMERICAN GAS ASSOCIATION, annual convention. Atlantic City. Oct. 11-14, 1954.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall meeting. Chicago. Oct. 11-15, 1954.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, south central regional meeting. Dallas. Oct. 12-15, 1954.

a hole here is annoying . . .



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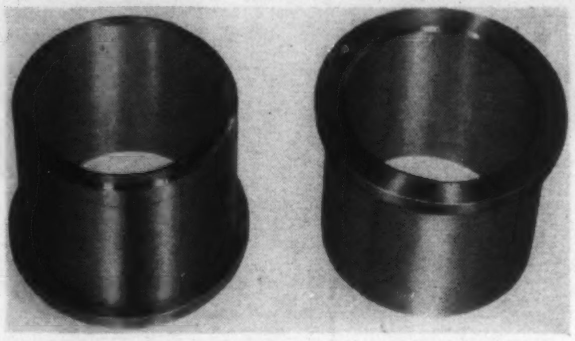

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News Digest

Titanium . . .

continued from page 8

are quite a few reasons why titanium is not catching on as fast as it might.

Scarcity

As yet there are no high volume sources of titanium in terms of the sources of aluminum or steel. The 5000 ton annual production could possibly be used up by a single airframe or jet engine manufacturer if full conversion to the metal was made. The general trend has been to make small parts, or a few large parts of titanium to gain experience with the metal without becoming too dependent on it. Curtis Wright, for example, is gradually phasing-in small engine components one at a time, and plans to continue at a slow pace.

New Production Properties

Too, titanium is an unknown factor in production. Few engineers are familiar with its properties in regard to forming and joining. Until recently, nearly all manufacturers using titanium in aircraft production reported that uniformity in alloys and commercially pure titanium was so poor that scrap and reject loss was incredibly high. At the April meeting of the SAE devoted to aircraft production, representatives of two different manufacturers gave contradictory reports of their personal experience with the metal. One said that all difficulties in homogeneity and quality control had been overcome in the last few months. The other reported that "you still don't know what you are getting from one ingot to the next." Whether the difficulty lies with the metal supplier or the manufacturer makes little difference as far as the end result is concerned—the difficulty is there and prospective users don't want to be burned.

Not a Panacea

Some of the lack of prospective users may also result from the gradual increase in technical information about the properties of the metal, which is resulting in a growing realization that no matter how cheaply titanium is produced in the future, it will remain a specialty metal—with exceptional corrosion resistance and strength weight ratio, of course—but a specialty metal nonetheless. Titanium was introduced in

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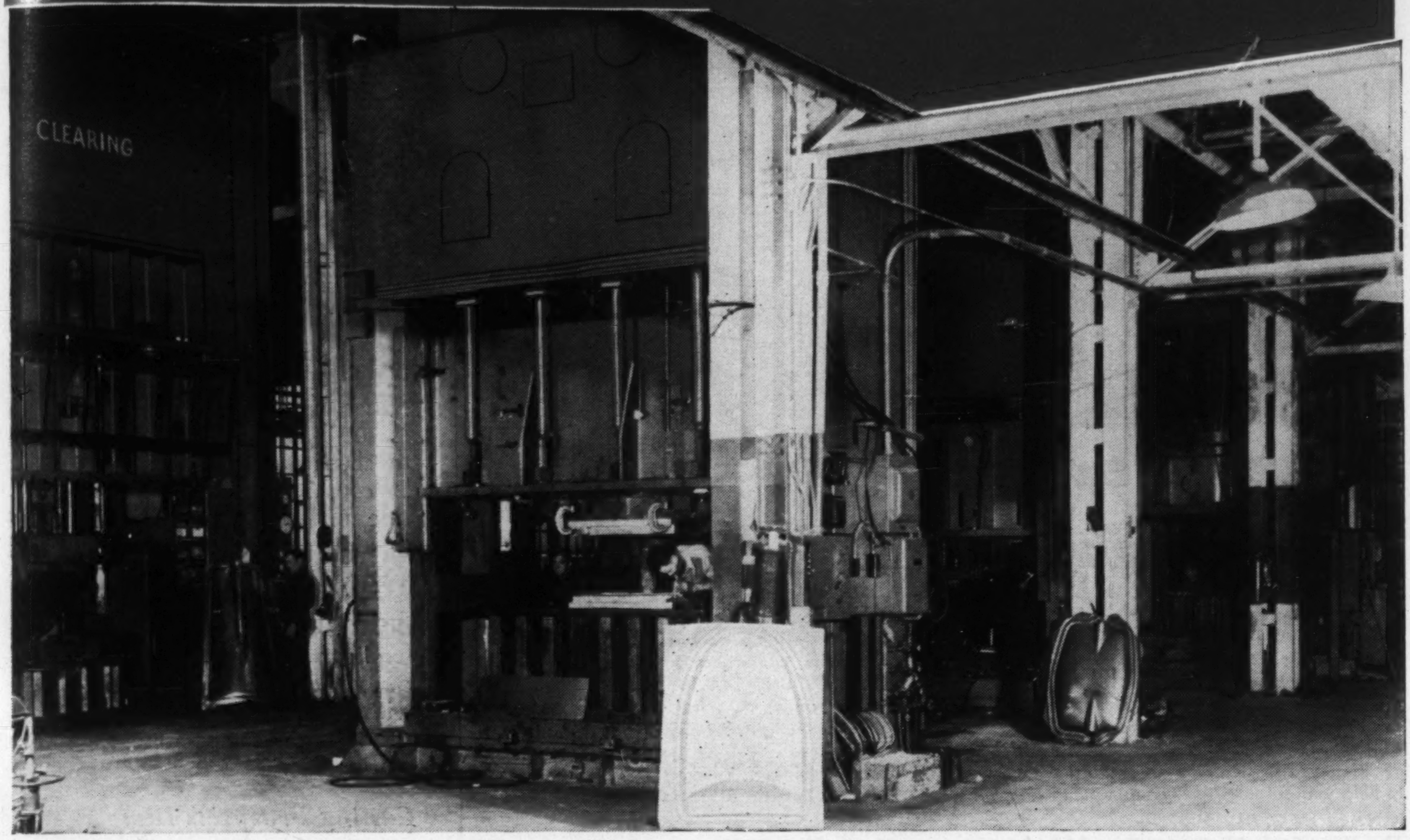

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Take Allied draw and form dies for producing prototype parts . . . such dies are made of either plastic or Allite (zinc alloy) depending on the number or type of pieces required. Cost and delivery is considerably less than that of production dies, yet accuracy is comparable in every way. Upon completion of the dies, prototype stampings are produced in Allied's press equipment, then trimmed, flanged and pierced by hand.

These prototype parts are another of Allied's die and stamping services which result in a dollar savings to you. We would appreciate your inquiry, or better yet a personal visit to our Plant Four in Hillsdale, Michigan, to show you such operations.

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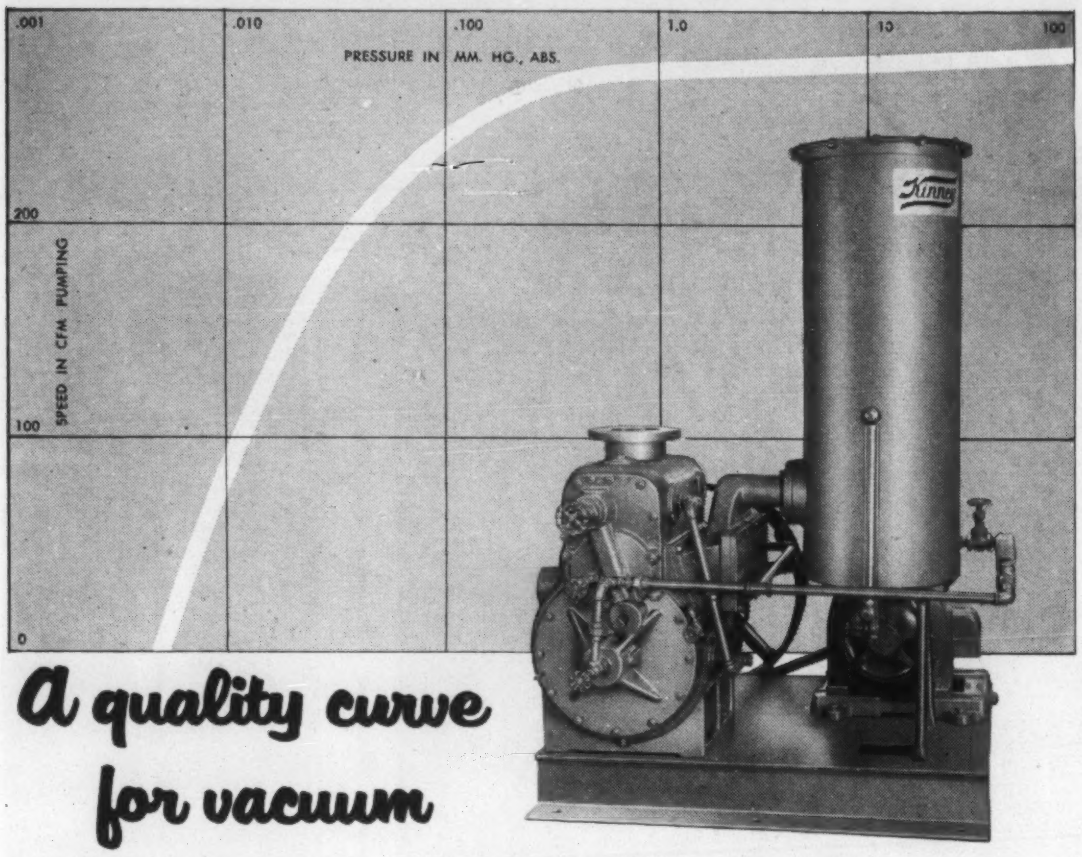

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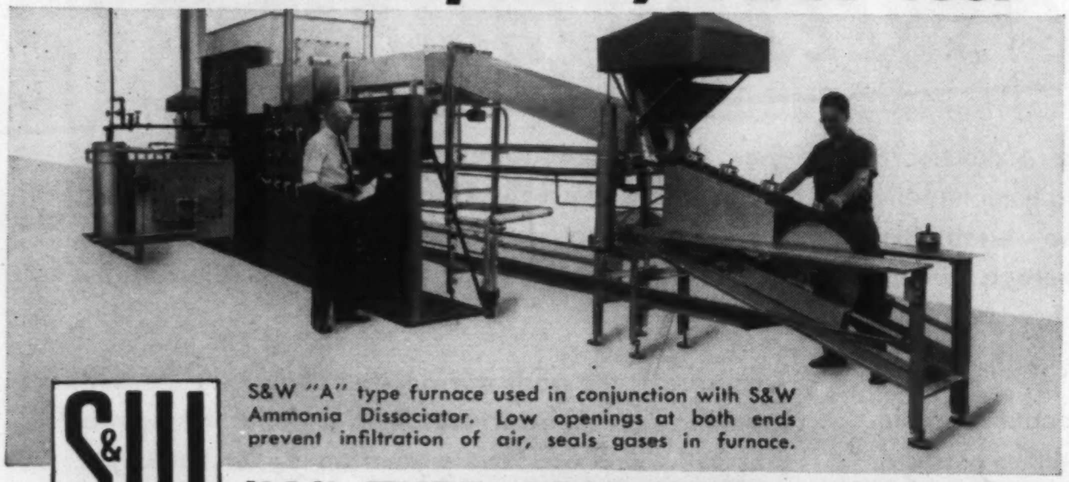

S&W "A" type furnace used in conjunction with S&W Ammonia Dissociator. Low openings at both ends prevent infiltration of air, seals gases in furnace.

S&W

"A" TYPE CONVEYOR FURNACE

In producing brazed or annealed work with a bright surface finish, you can sharply cut operating costs by reducing atmosphere volume required. With this S&W full muffle wire mesh conveyor belt furnace you get uniform high quality production, combined with lower operating cost than is possible with conventional straight-through type furnaces. Of special interest to stainless steel processors, it is particularly suited for such high production heat treating operations as bright annealing, bright hardening, bright brazing and case hardening. Ask for our interesting data on how this cost-cutting S&W furnace is currently used to do better work at lower cost.

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One S&W "A" Type Furnace now used to bright copper braze stainless steels has 8" clearance above belt — contradicting usual belief that working height of constantly opened furnace doors must be less than 3" to get bright work. Ask about other ingenious installations.

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the popular press as a metal that would be all things to all people . . . a sort of superalloy with wings . . . the "wonder metal!" Since then a lot of fabricators have discovered that titanium fits in a rather narrow intermediate position between aluminum and steel in the family of metals.

Not for High Temperature

Touted as a high temperature material, metallic titanium shows a rather disappointing drop in strength at 700 F and its alloys are good only to about 900 F at present. It may be considered a good high temperature material only when compared to aluminum and magnesium; it is not intrinsically a high temperature material, and even its alloys have the disquieting tendency to dissolve their oxides and become brittle at temperatures in excess of 1000 F. They share with molybdenum the need for a good high temperature protective coating.

Casting Prospects Dim

Some progress has been made in casting titanium in the laboratory, but it must be handled in a vacuum or inert atmosphere and no mold material is available which will not contaminate the metal. Titanium is almost a universal solvent when molten and it combines with all known crucible materials. Even melted in graphite, the carbon content quickly goes above the acceptable level. Few predict that it will ever be practical to cast titanium in large quantities at reasonable cost.

Scrap Recovery

Until recently there has been no practical method for remelting titanium scrap, which added considerably to the cost factor in titanium fabrication. The development of skull melting, using a shell of titanium as a crucible, promises to permit some scrap recovery, though only certain types of scrap can be remelted. Vacuum furnaces or inert atmospheres must of course, be used in melting the highly reactive metal.

The Uniformity Blues

Titanium fabricators have been, and in some cases still claim to be plagued with varying physical properties of finished titanium. Recent reports indicate that the problem is being solved, after a fashion, by double-melting, using forged and

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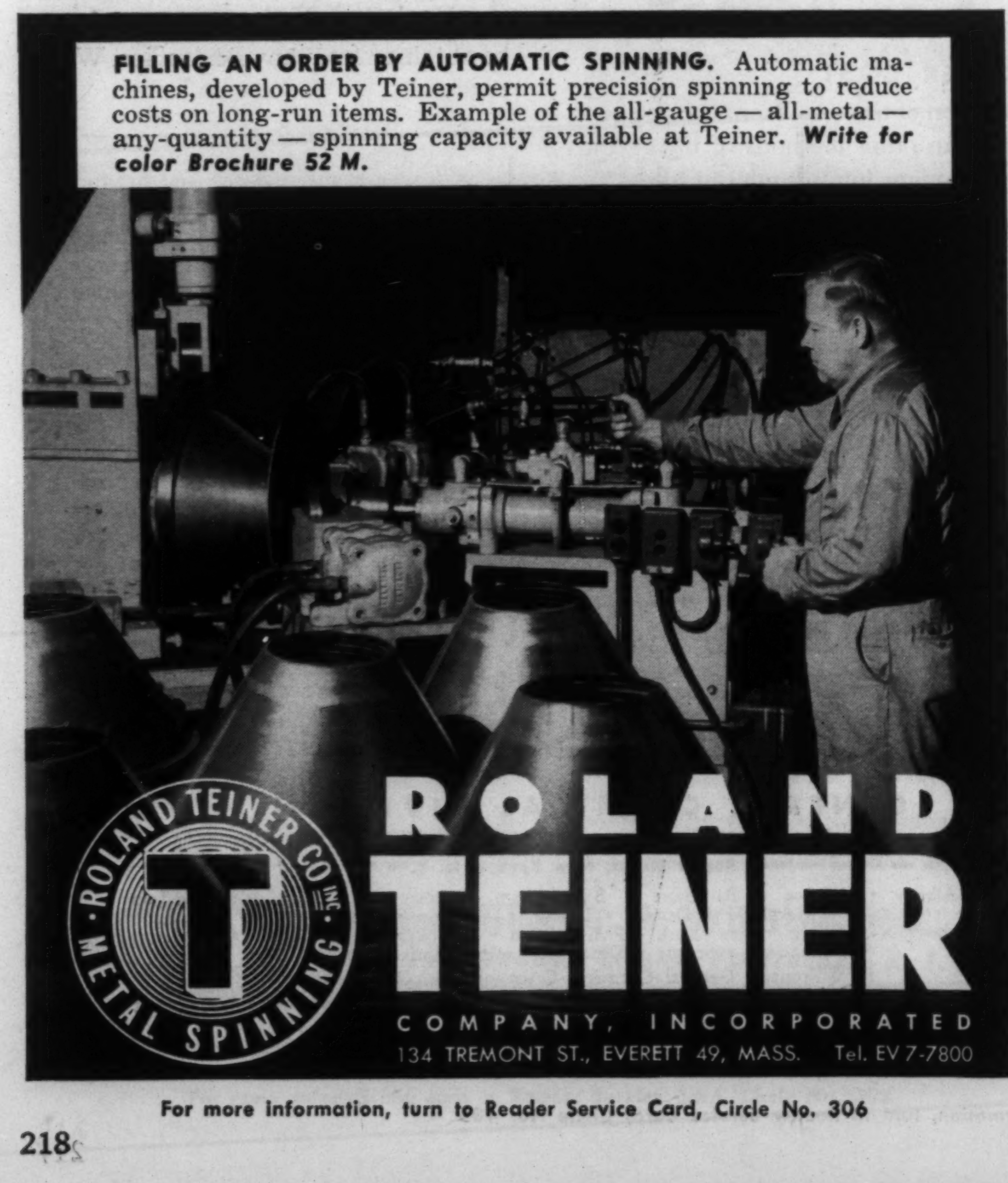
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machined consumeable electrodes for the final melt. The process works, but virtually doubles the cost of the alloy.

Airframe Industry Survey

Despite the high cost and current difficulties accompanying the use of titanium, airframe manufacturers are enthusiastic about its future. A survey by the Aircraft Industries Association reveals that airframe manufacturers are presently working on designs requiring an average of 5% titanium by weight. Long range future requirements for titanium and its alloys were placed at about 35% of airframe weight on the average throughout the industry. However, the long range figure must be taken with a large grain of salt. The construction of the survey allowed manufacturers to estimate how much titanium alloy they would use *if*—and it is a big if—titanium alloys had properties which were desirable, but not yet available.

Titanium's Competition

Titanium does not cut such a broad swath with its high strength-weight ratio that other metals and alloys are out of the running. Steels, heat treated to strengths of 230,000 psi equal the strength-weight ratio of titanium, and, according to Wright Air Development Center, the prospect of using precipitation hardened steels with strengths in the range of 280,000 psi is not unlikely. Compared to light metals, titanium alloys are not superior in strength weight ratio to some aluminum alloys if the buckling factor is not critical. Titanium has a definite advantage over aluminum and magnesium at temperatures in the range of 700 F, however.

Production

The government's buying program will assure full scale operation of all titanium facilities in 1954. The stockpile accumulated, plus several new companies due to enter the sponge production field, will eliminate the danger of scarcity at least as far as airframe and engine manufacturers are concerned. This should help to encourage plans for greater use of the metal.

Development of better alloys and continued production of uniform finished stock will build more confidence in the material and allow production methods and controls to be

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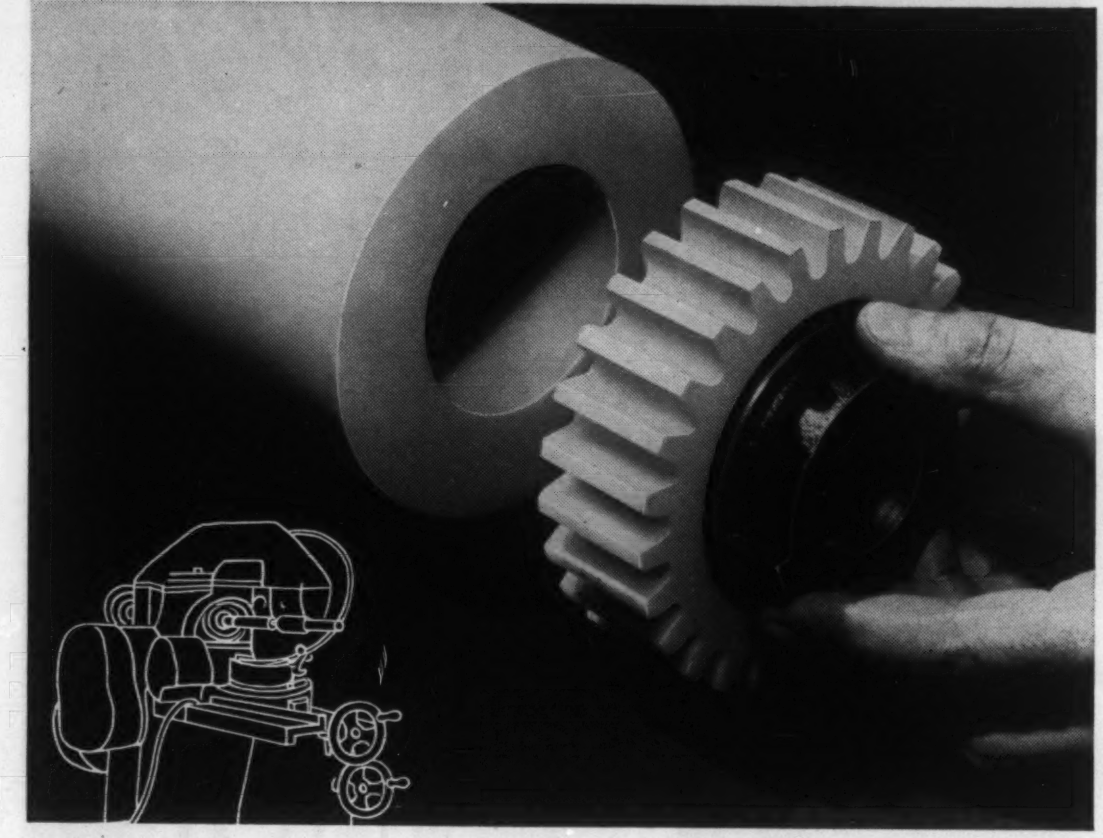

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- Economical fabrication of one part or thousands on standard metalworking tools in your own shop
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standardized. In the next year or two, titanium will go through its most critical trials. The metal has passed its initial acceptance hurdle, manufacturers are anxious to use it, and the final evaluation will depend, as always, on how it compares with competing materials in production costs.

ASTM to Meet in Chicago

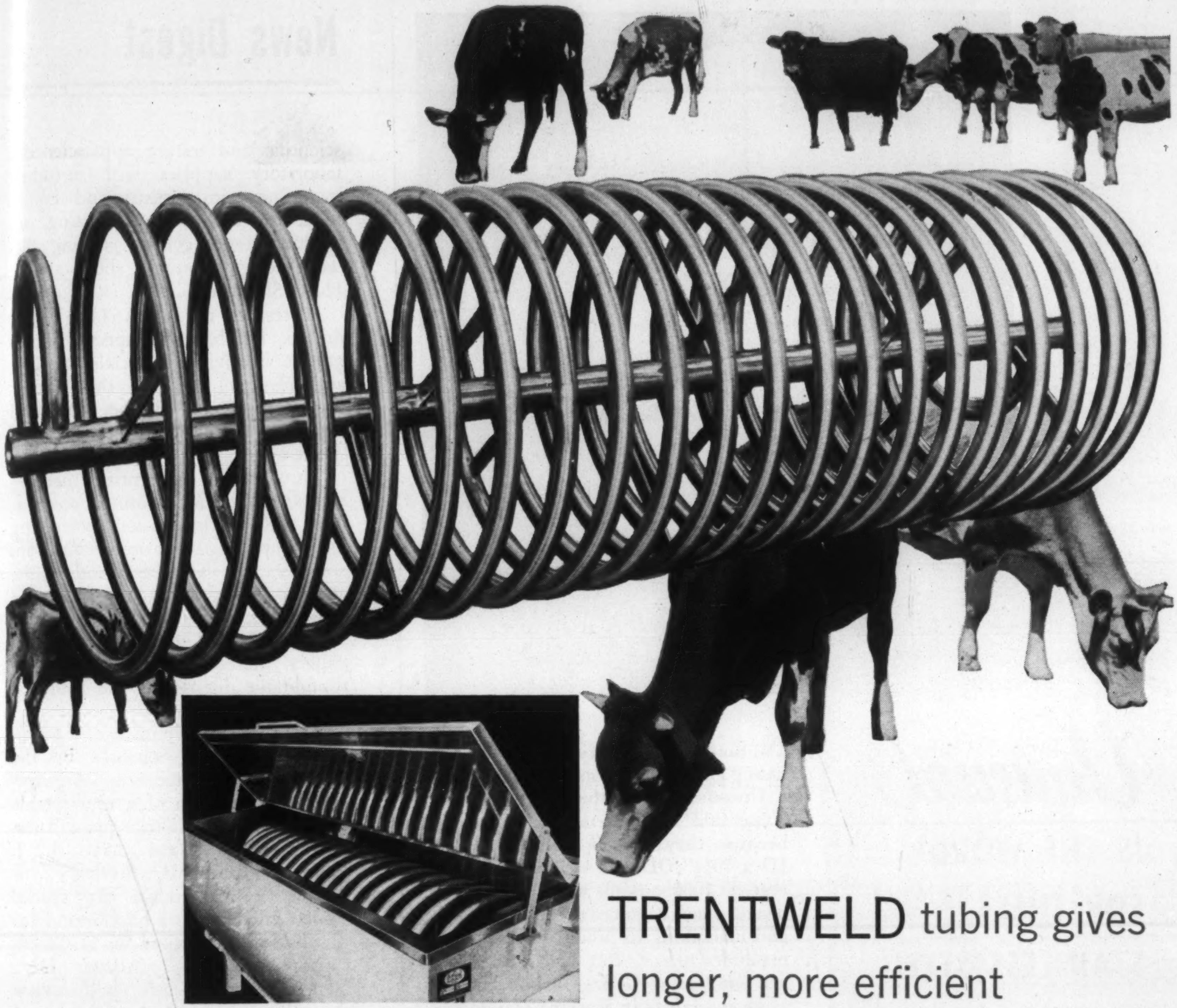
The American Society for Testing Materials will hold its 57th annual meeting in Chicago, June 13-18. The Society has scheduled six technical symposiums and thirty six technical sessions for the five day meeting. In addition, there will be in progress throughout the week the Society's 11th exhibit of Testing and Scientific Apparatus and Laboratory Supplies, and the 9th Photographic Exhibit, which will have the theme of Materials, Testing and Research. Headquarters for the Meeting and Exhibits will be the Hotels Sherman and Morrison.

The 28th Edgar Marburg Lecture (Wednesday afternoon, June 16) will be an important feature of the program delivered by Harold F. Dodge, Quality Results Engineer, Bell Telephone Laboratories, Inc. Mr. Dodge, a pioneer and leader in the field of statistics and quality control, will discuss the subject "Interpretation of Engineering Data."

R. L. Templin, ASTM Past President, Director of Research and Chief Engineer of Tests, Aluminum Company of America, will present the 3rd H. W. Gillett Memorial Lecture (Tuesday afternoon, June 15) on the subject "Fatigue of Aluminum."

Beginning Sunday, June 13, and extending through Friday, June 18, there will be an estimated 600 meetings of the various ASTM technical committees. Several of these committees have cooperated in developing the technical symposiums featuring the ASTM program.

The 11th Exhibit of Testing and Scientific Apparatus and Laboratory Supplies will be the largest in ASTM history. More space has been applied for than ever before with applications for 78 booths received to date. Some 57 of the country's leading manufacturers and distributors of



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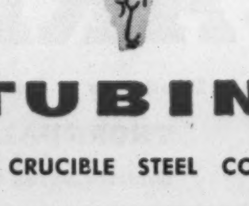

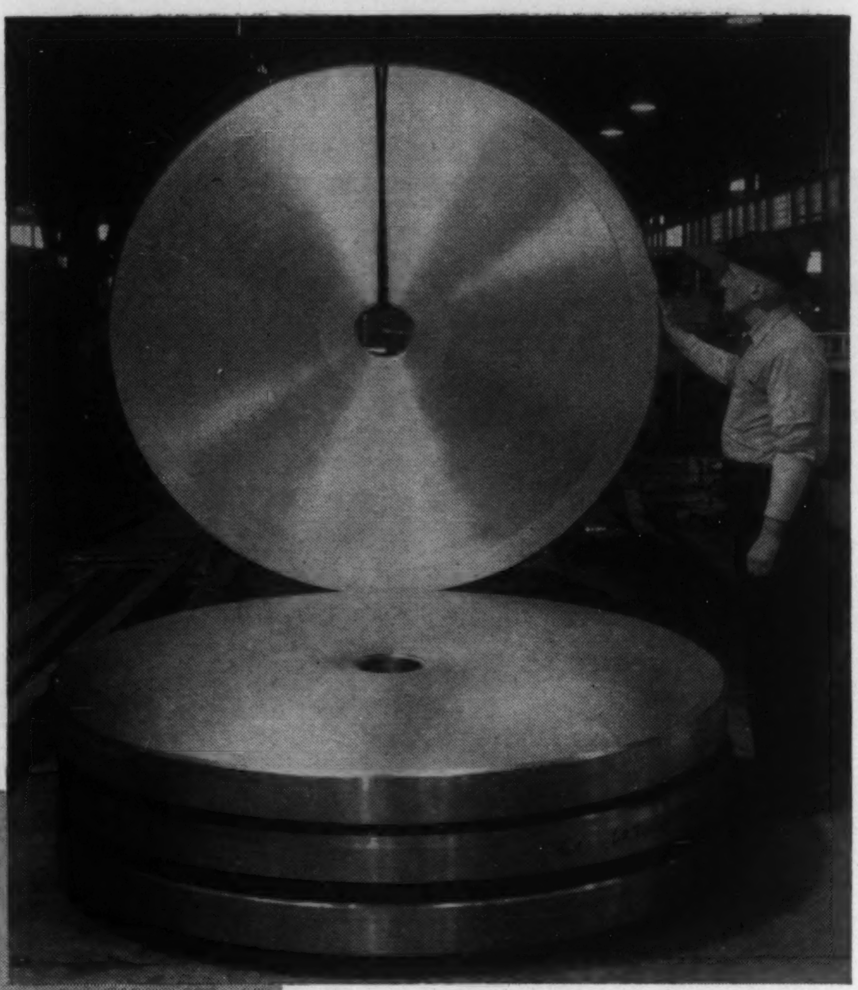

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News Digest

scientific and testing apparatus and laboratory supplies will introduce many new instruments and equipment for measurement, testing, inspection, and control during the week long apparatus show at the Hotel Sherman.

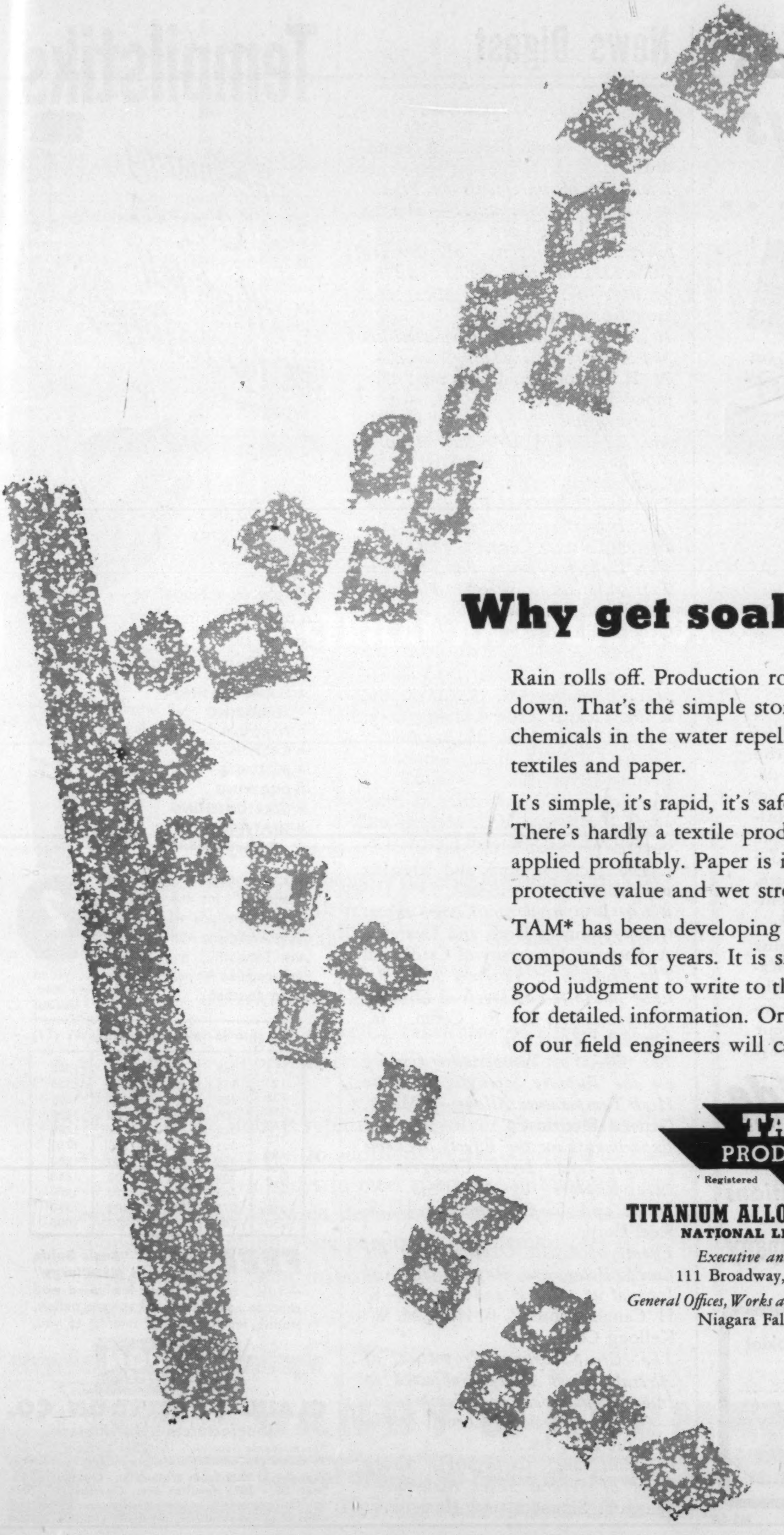
A feature of the ASTM Photographic Exhibit, with special photographs involving materials, testing, and research, will be the Traveling Print Show of the Technical Division, Photographic Society of America.

Throughout the entire meeting scores of ASTM technical committees will be in session perfecting and completing work on specifications and tests that have been under way, and initiating new research and standardization work. In addition to symposiums and groups of technical papers, there will be a number of round-table discussions and informal sessions.

A session, Significance of Specifications, will be sponsored by the Chicago Committee on Arrangements in the form of a round table discussion and will take place Tuesday morning (June 15). R. J. Painter, Executive Secretary of ASTM, will introduce the special subject and present a background for the discussion. Arthur W. F. Green, Chief Metallurgist, Allison Div., General Motors Corp., will review the subject from the standpoint of the consumer of materials; A. O. Schaefer, Vice-President in Charge of Engineering and Manufacturing, The Midvale Co., will present the producer's viewpoint; and Captain C. R. Watts, Staff Director, Standardization, Department of Defense, (Logistics and Supply) will present information and reactions from the viewpoint of the Defense Department. The discussion will highlight the increasing importance of standardization and research in materials as viewed by the producer, the consumer, and by branches of the Armed Services.

The symposiums of greatest interest to those concerned with engineering materials are the Symposium on Temperature Stability of Electrical Insulating Materials and the Symposium of the Effect of Cyclic Heating and Stressing on Metals.

Papers to be delivered at the Insulation Symposium include: *Measurements of Dielectric Properties at Temperatures Up to 500 C*—A. H. Scott, P. Ehrlich, J. F. Rich-



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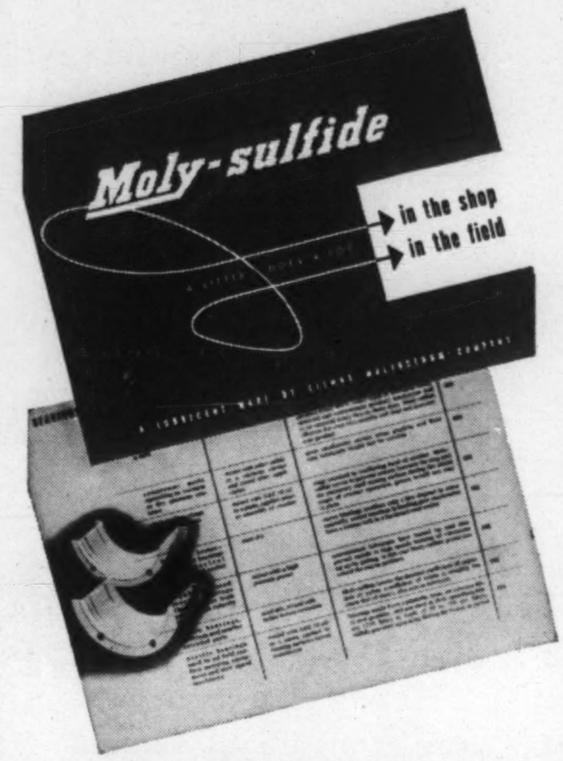
154 ideas on ways to use...



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News Digest

ardson, National Bureau of Standards.

Dielectric Measurements on Plastics at High Temperatures—Thomas Hazen, Bakelite Corp.

Electrical Resistivity of Bonded Micaceous Materials at Elevated Temperature—K. Wechsler, Mica Insulator Co.

High Temperature Characteristics and Stability of Insulating Varnish—A. H. Haroldson, Continental Diamond Fibre Co.

Thermal Stability of Insulating Fabrics, an ASTM D-9 Subcommittee VII Report—R. C. Bartlett, Natvar Corp.

Thermal Stability of Polyvinyl Chloride Insulating Compounds—R. C. Bartlett, Natvar Corp.

The Deflected Beam Film Rupture Test Applied to Sheet Insulation—K. N. Mathes and H. T. Morgan, General Electric Co.

A Method for Evaluation of the Thermal Aging Stability of Flexible Sheet Insulation—C. G. Currin and R. M. Plettner, Dow Corning Corp.

Aging of Silicone Treated Glass Cloth—O. E. Anderson, Continental Diamond Fibre Co.

Heat Aging Characteristics of Insulating Varnishes—H. I. Morgan and K. N. Mathes, General Electric Co.

The cyclic heating and stressing symposium will include:

What We need to Know About Creep—John E. Dorn and Lawrence A. Shepard, University of California.

The Problem of Thermal Stress Fatigue in Austenitic Steels at Elevated Temperatures—L. F. Coffin, Jr., General Electric Co.

The Effect of Temperature Cycling on the Rupture Strength of Some High Temperature Alloys—J. Miller, General Electric Co.

Experiments on the Effects of Temperature and Load Changes on Creep-Rupture of Steels—G. V. Smith and E. G. Houston, U. S. Steel Corp.

Effects of Cyclic Overloads on the Creep Rates and Rupture Life of Inconel at 1700 F and 1800 F—R. H. Caughey and W. B. Hoyt, M. W. Kellogg Co.

The Creep-Rupture Properties of Aircraft Sheet Alloys Subjected to Intermittent Load and Temperature—G. J. Guarnieri, Cornell Aeronautical Lab., Inc.

Constant and Cyclic-Stress Creep Tests of Several Sheet Materials—Ward F. Simmons and Howard C.

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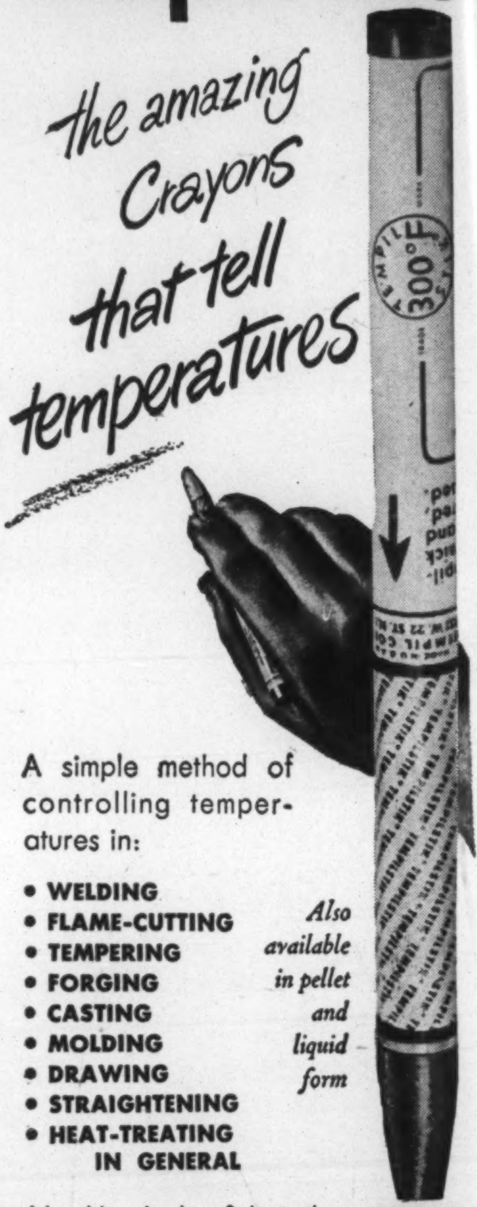
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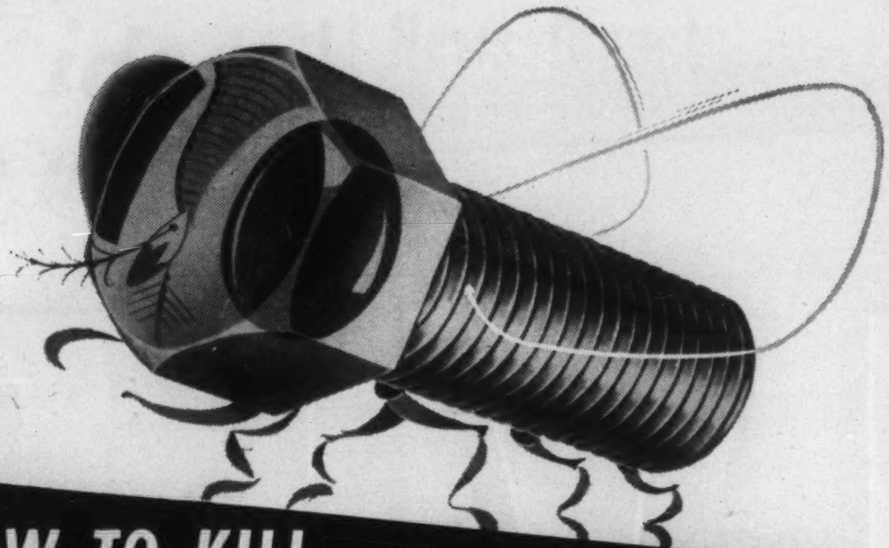

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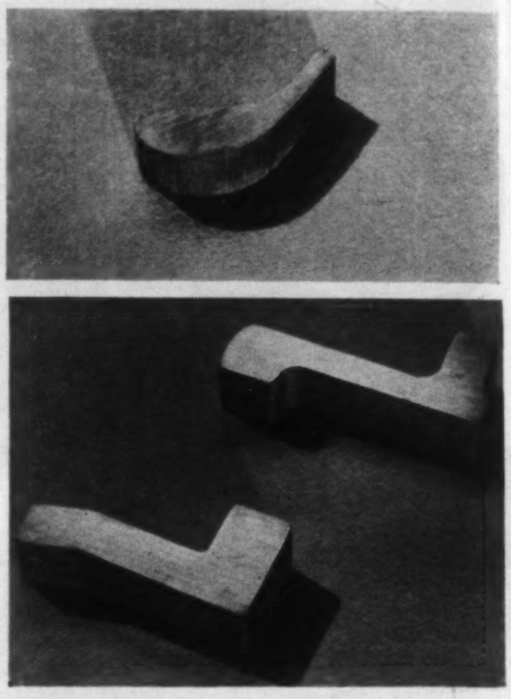
Cross, Battelle Memorial Institute. *The Effect of Cyclic Temperature on the Scaling Behavior of Heat-Resisting Alloys*—H. E. Eiselstein, International Nickel Co., Inc.



Hot extruded high alloy steel section.

Steel Extrusion in Wider Use

Increasing success with hot extrusion of steel has put the process in a much stronger position as an alternative to rolling or machining small production lots of special shapes.

Allegheny Ludlum reports that extrusion of tough stainless steel grades for jet engine rings may be one of the most important achievements of the hot extrusion department at its Watervliet, N. Y. plant. The company has shown a variety of complex shapes produced for aircraft use that demonstrate the flexibility of the process in forming high alloy and high temperature materials.

From a cost standpoint, the two factors that indicate the use of hot extrusion are: 1) a volume (roughly under 10 tons) which does not justify the cost of special rolls and 2) small lots of complex shapes from expensive high alloy steel.

In the case of small lots, the extrusion process offers substantial advantages. Rolling mills generally are not anxious to take orders for less than 10 tons of a rollable shape, and the customer is charged for lost pro-

uniform heat . . .
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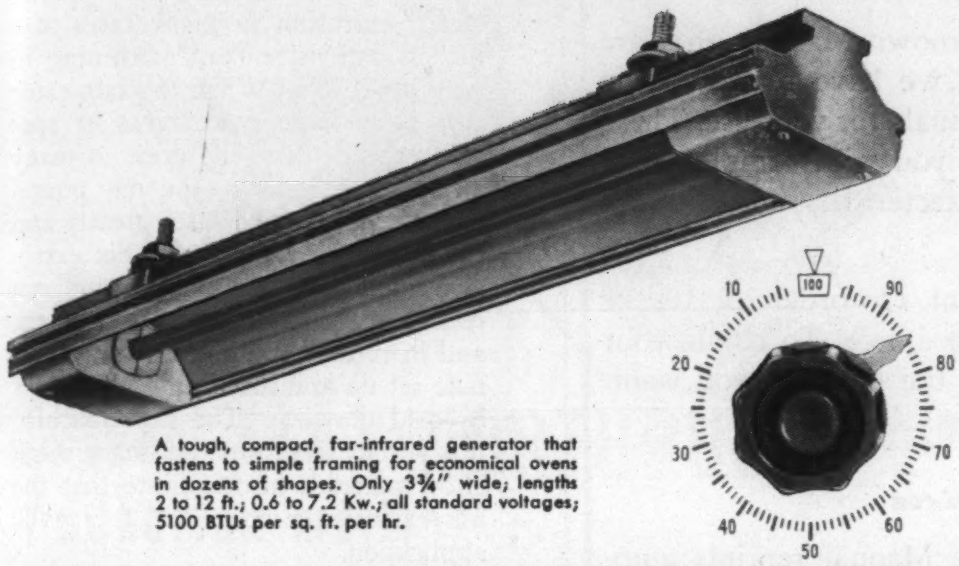
fast heat . . .
"color blind" heat . . .



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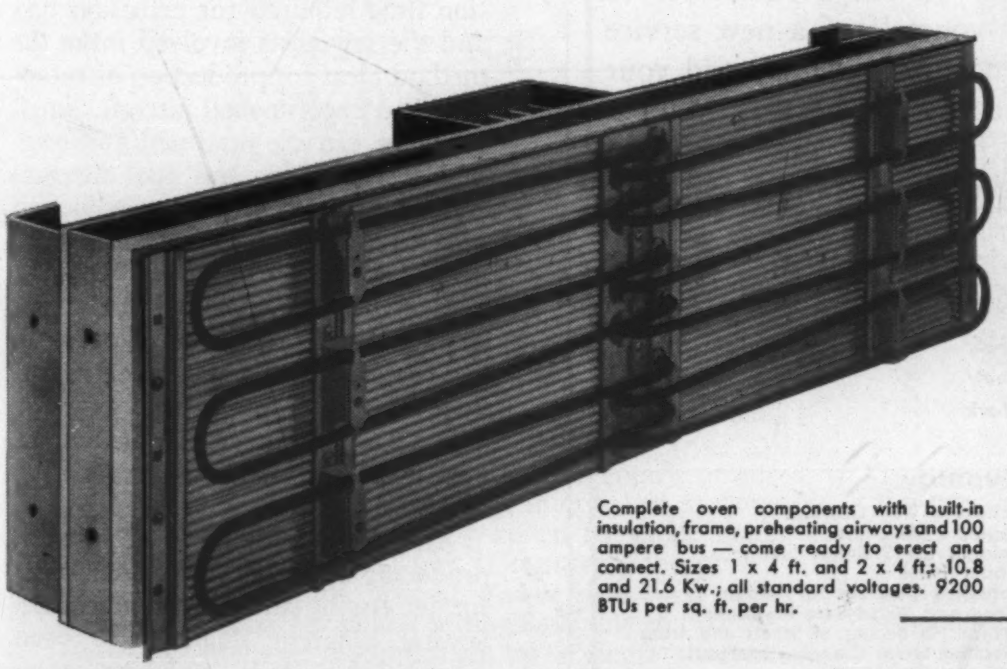

Complete oven components with built-in insulation, frame, preheating airways and 100 ampere bus — come ready to erect and connect. Sizes 1 x 4 ft. and 2 x 4 ft.; 10.8 and 21.6 Kw.; all standard voltages. 9200 BTUs per sq. ft. per hr.

A Chromalox Electric Radiant Panel or Chromalox Radiant Heater installation gives you a quick, low-cost answer to your baking, curing, drying and other heating needs. Pre-engineered units allow on-the-spot erection and connection. You get up to 700° F. work temperatures; absolutely uniform radiation with no hot and cold spots; high intensity heat that's absorbed *f-a-s-t* by all colors; and accurate "dialed" heat from 0 to 100% of capacity.

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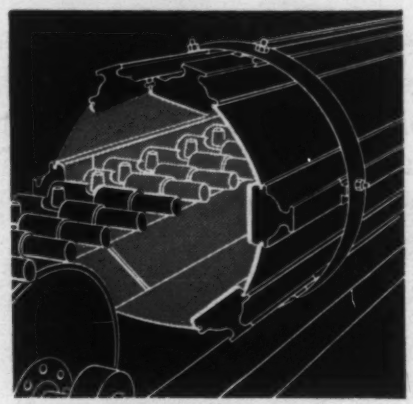
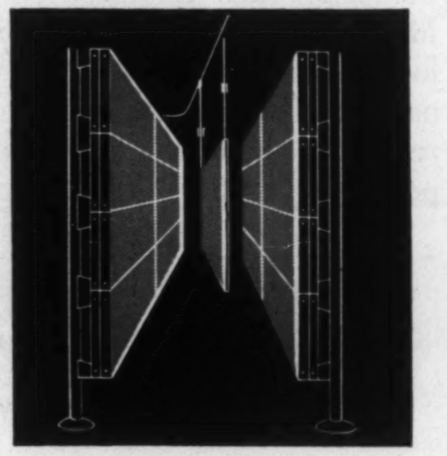


Conveyorized oven built on the job using Chromalox Radiant Heaters. Units are installed in lengths and ratings needed to fit the work. Input controller gives precise and exact temperatures easily adjusted to meet varied processing requirements. Easy to assemble, easy to wire.



Chromalox pre-engineered Radiant Panels are easily and quickly erected and connected to form ovens and drying tunnels of any size and shape. An oven such as sketched may be installed in 20 to 30 man-hours with minimum engineering expense and lowest cost per installed kilowatt.

Have a Problem Involving Degreasing, Drying, Baking, Preheating, Curing?

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duction time for roll changes as well as the expense of cutting special rolls, which can amount to thousands of dollars. Hot extrusion dies, on the other hand, cost relatively little, and there is little production loss involved in changing from one shape to another on the press.

In the case of high alloy special steels, extrusion in many cases may be less expensive than machining in very small lots. When the fabricator cuts away large percentages of special steels, as must be done in many aircraft components, the net pound cost of the part increases greatly and the inherent advantages of hot extrusion come into focus. Extrusion can reduce machining time on some parts, and in certain applications can eliminate set up and machining altogether by cold drawing. The slow machining speeds necessary on many high alloy materials also indicate that the hot extrusion process will find wide application.

The comparatively short production time required for extrusion dies and the low costs involved make the method ideal for production of prototype and experimental aircraft. Small tonnages can be produced for original test models, and the dies are readily available for production quantities at a later time if they are needed.

Harvey Aluminum, one of the pioneers in the hot extrusion of steel, has reported savings in the neighborhood of 75% for some parts for the F-89. The process and costs were reported in detail in the February issue of M&M.

Allegheny Ludlum is at present producing a number of different parts for jet engine and non military use. Several different shapes have been extruded for rings, and one extrusion is being used for chain links in place of forged links previously produced. The extruded shape is cut into sections and drilled at each end to form links.

A non-military part in the preproduction stage is a receiving cylinder for soldering tin cans. Two extruded pieces of type 316 stainless are joined to make a cylinder, which was previously made of carbon steel which had to be machined, polished and plated. Only finish machining of the stainless extrusion is necessary and the part is expected to have a much longer life.

The grain structures of as-rolled and as-extruded sections compare

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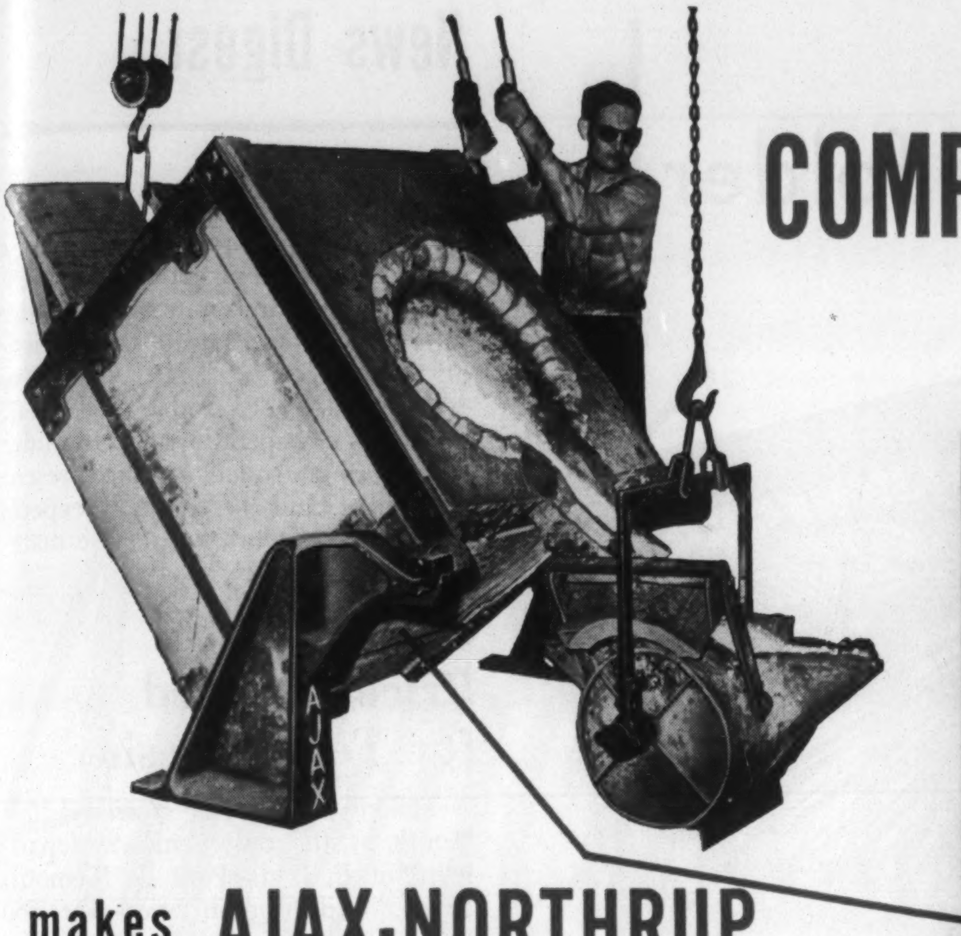

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favorably, according to Allegheny-Ludlum. They report no major problems with segregation. At present the company is extruding the following alloys as well as a variety of tool steels: 405, 410, 403, 430, 303C, 304, 321, and 310. Small quantities of superalloys and titanium have been extruded on the present equipment, and the company expects to increase its work with those materials in the future.

Price Lowered for Teflon Resin

Teflon prices were lowered last month by the polychemicals department of E. I. du Pont de Nemours & Co. Reduction in prices for 240 lb containers ranged from 40¢ per lb for molding powder to $1.00 per lb for resin for dispersions. Fine "Teflon" powder for extruding tape and wire coatings was reduced 50¢ per lb.

Representative prices after reduction for the corrosion resistant, high temperature tetrafluoroethelene resin in 240-lb lots are: $5.35 per lb for fine extrusion powder, $5.10 for Teflon-1 molding powder, and $8.00 per lb for 3074 dispersion powder.

Price cuts were made possible, the company said, by improved efficiency in its new Parkersburg plant and increased volume of business resulting from wider use of the plastic.

Nuclear Engineering Congress Planned

The Nuclear Engineering Division of the American Institute of Chemical Engineers will hold a Nuclear Engineering Congress at the University of Michigan, Ann Arbor, Michigan, June 20-25. The meeting will consist of a series of five daily technical sessions, to which leading scientists from the field of nuclear energy will present summaries of their research work. Approximately 110 papers will be heard at the meeting. In a concurrent exhibition, about 50 exhibitors from industrial and educational fields will have displays featuring non-military uses of nuclear energy and equipment associated with nuclear research and production.

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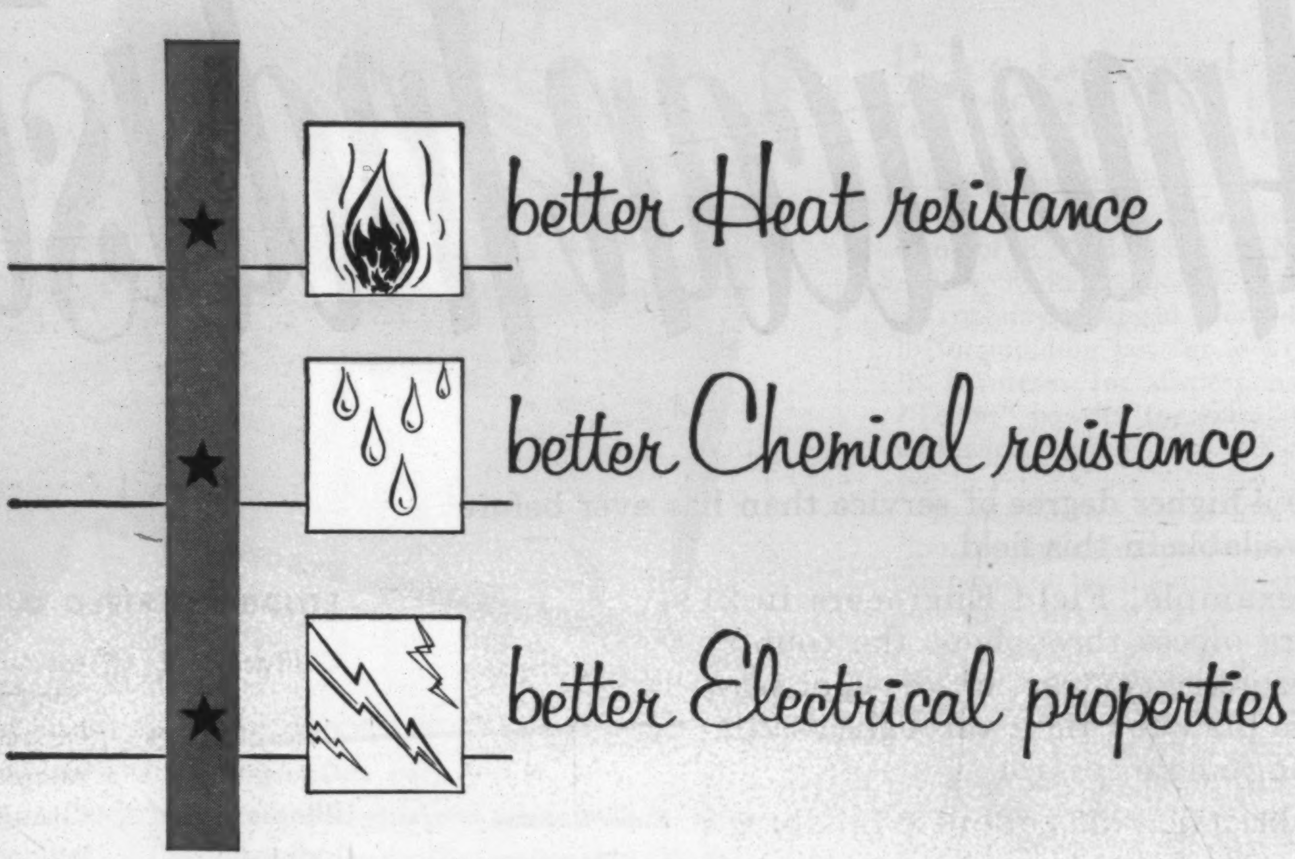

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Your request will bring you a sample of Epon resin 828 and Curing Agent CL for evaluation, as well as a copy of Technical Bulletin SC:54-10. Write for them—today.

Curing Agent CL is Shell Chemical Corporation's name for metaphenylene diamine. We do not manufacture Curing Agent CL. It is available in commercial quantities from E. I. du Pont de Nemours & Company and National Aniline Division, Allied Chemical & Dye Corp.

*A development of Shell Chemical laboratories. Patent applied for.

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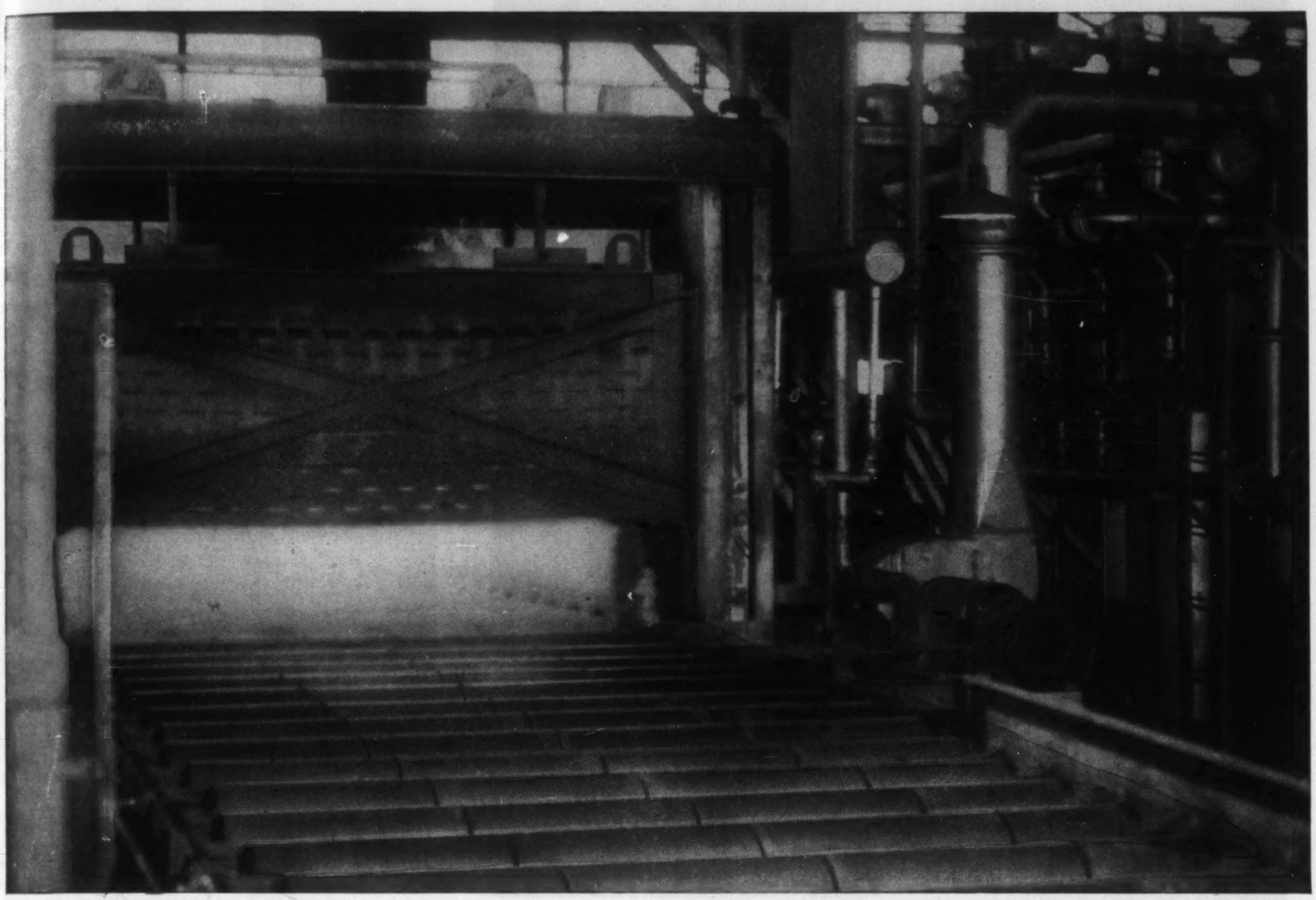


3800 hours at 2150 deg. F.

The Hastelloy alloy X rollers in this gas-fired heating furnace have been in use for 3800 hours. They operate in a neutral atmosphere at 2150 deg. F. They are also subjected to mechanical and thermal shock as they come in contact with the cold sheet metal being heated. A recent inspection showed that the Hastelloy alloy X parts are still in excellent operating condition.

The rollers were fabricated from Hastelloy alloy X sheet, 3/16 in. thick. The sheets were formed into shells 7½ in. in diameter and six feet long. The shells were then slipped over 2-in. water-cooled pipe, and refractory material was packed into the space between the shells and shafts. Spiders on the shafts were used to keep the shells concentric.

Hastelloy alloy X has excellent forming characteristics, and good creep and stress-rupture properties. At 1200 deg. F. this nickel-base alloy has an ultimate strength of 82,000 lb. per sq. in., and even at 1500 deg. F. the ultimate tensile strength is 48,000 lb. per sq. inch. Its outstanding resistance to oxidizing, reducing, or neutral atmospheres makes it especially useful in furnace applications.

For information on prices, sizes, and properties of Hastelloy alloy X write to any of the district sales offices listed below.

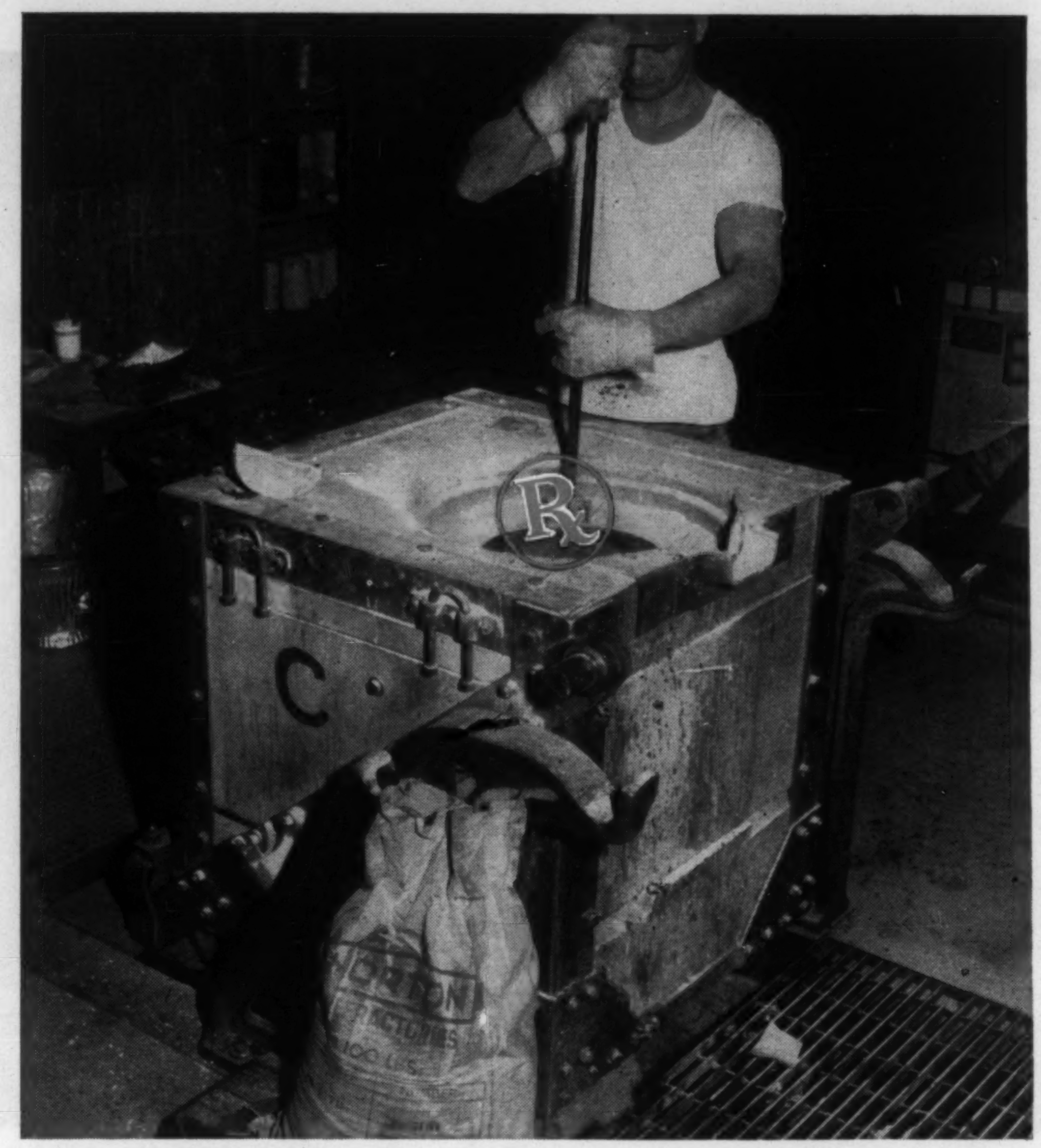
"Hastelloy" and "Haynes" are registered trade-marks of Union Carbide and Carbon Corporation.

HAYNES
TRADE-MARK
ALLOYS

HAYNES STELLITE COMPANY
A Division of Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

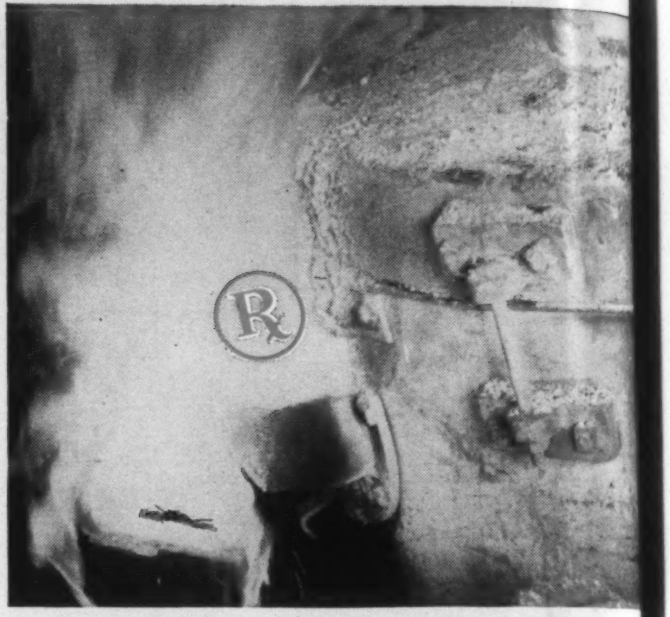
For more information, turn to Reader Service Card, Circle No. 401

℞ for



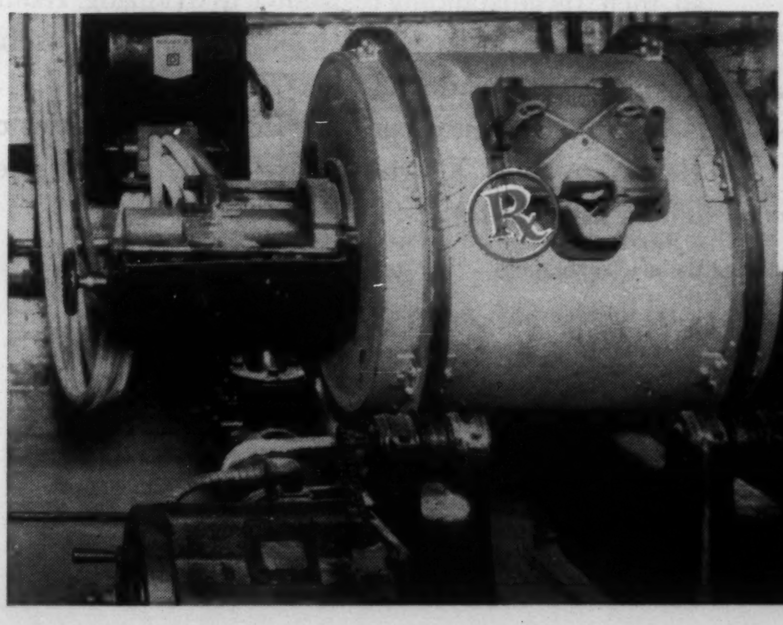
For High Frequency Furnaces. Norton MAGNORITE cement has been especially engineered for dry ramming and for withstanding temperatures up to 3250°F. Also, its slight expansion on maturing eliminates shrinkage cracks which might lead to furnace failure. It's the ideal prescription for lining high frequency induction furnaces handling melts of high temperature alloys.

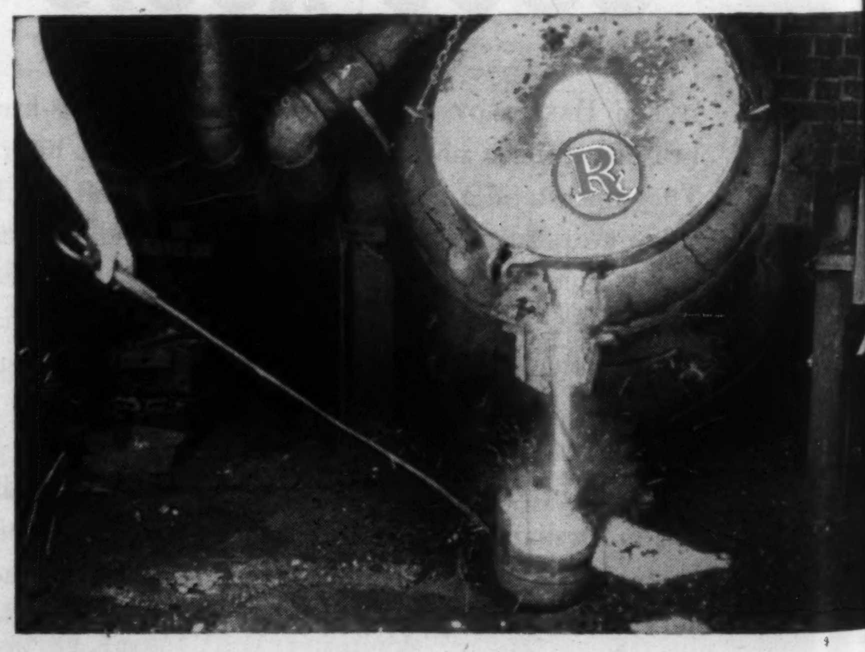
Other Norton refractories for high frequency furnaces include FUSED STABILIZED ZIRCONIA crucibles for melting platinum and its alloys. They are not wetted by the metal, enabling you to recover 100% of the melt without destroying your crucibles, or to re-use the crucibles for different alloys without contamination.



For Low Frequency Furnaces. The furnace shown here has a special MAGNORITE cement lining. ALUNDUM cement is also widely used in low frequency induction furnaces. Whatever you're melting, including such refractory alloys as cupronickel and nickel silver, high copper alloys and Al, Te and Si bronzes, one of these two Norton ℞'s is engineered to give you longer lining life — plus the high rammed density that resists metal penetration, erosion and chemical attack.

For Crucible Type Furnaces. The cover of this tilting crucible furnace and its cement lining are both made of CRYSTOLON refractory material, engineered for the user's particular needs. CRYSTOLON linings offer effective protection against flame erosion and thermal shock.





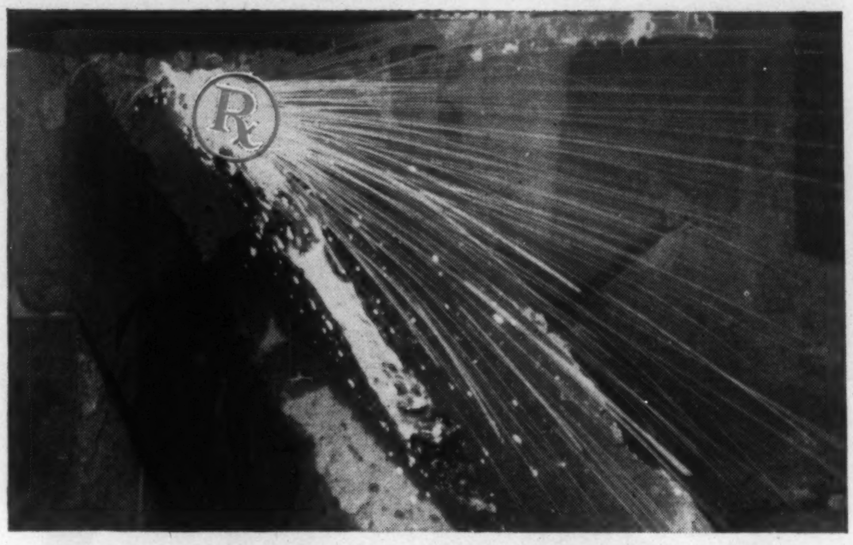
For Indirect Arc Furnaces. This installation owes much of its high production rate to its lining of correctly-engineered ALUNDUM cement. More and more foundries report excellent results with ALUNDUM and MAGNORITE crocks, covers and cements — engineered and prescribed for their individual metal processing needs. Norton prescriptions will save *you* time, trouble and money, too!

higher production . . better products . . . lower costs

Norton refractories are engineered for top performance—prescribed for many metal processing applications

Norton refractory products are *engineered* to give you the best possible ℞'s — the most effective combinations of physical, chemical and thermal characteristics — for your particular refractory uses.

Norton ALUNDUM*, CRYSTOLON*, MAGNORITE* and FUSED STABILIZED ZIRCONIA refractory materials are made into shapes and cements to meet your requirements. For the ℞'s *you* need to improve your processing — and for expert aid in any refractory problem — call in your Norton Refractories Engineer. And write for helpful literature to NORTON COMPANY, 345 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Canada.



For Cupola Type Furnaces. For back slagging cupolas, the Norton ℞ is CRYSTOLON slag hole blocks, as shown. For capping the notch and lining the slag chute in front slagging cupolas, CRYSTOLON bricks and cement are prescribed. This refractory material is engineered to give exceptionally long service life at temperatures up to 3050°F. It has great resistance to slag penetration and chemical attacks—and 5 to 15 times the resistance of ordinary fire clay to erosion and corrosion.

NORTON

REFRACTORIES

Engineered . . . ℞ . . . Prescribed

Making better products . . . to make other products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

For Reverberatory Furnaces. The ℞ for this reverberatory furnace is Norton CRYSTOLON refractory cement, engineered for maximum service life of this particular metal-melting job.

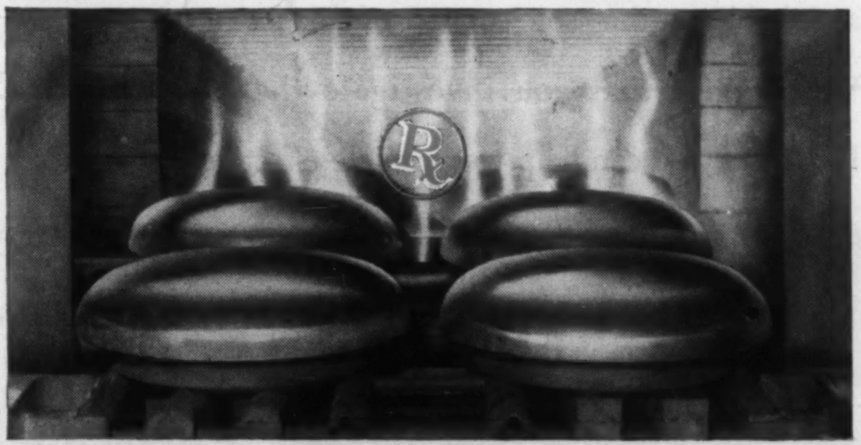
Other Norton Prescriptions

are helping metal processing plants to maintain schedules with minimum shut-downs. For example:

Heat-Treating And Sintering Furnaces operate at higher temperatures and lower costs, thanks to a wide variety of ALUNDUM and CRYSTOLON refractory products. Hearth plates, pier brick, burner blocks, muffles, muffle plates, skid rails, recuperator tubes, burner-tunnel and embedding cements combine high refractoriness with excellent thermal conductivity and resistance to spalling, erosion and corrosion.

Desulphurizing Ladles which require addition of sodium carbonate gain consistently longer lining-life when ALUNDUM cement is used. One gray iron foundry, using a 1500-lb. U-type ladle reports that ALUNDUM cement lasts two to four times longer than other linings, month in and month out.

Steel Ladles show equally successful results when lined with ALUNDUM cement. One plant, using it in a 1000-lb. teapot ladle to handle stainless steel, stepped up the number of heats from 47 to 103.



For Electric Furnaces. Furnace equipment of this type operates at lowest performance and maintenance costs when CRYSTOLON heating elements — Norton "Hot Rods" — are installed. They're the newest Norton ℞, engineered and prescribed for electric furnaces. They can be used to replace your present rods — and have proved their ability to deliver two to four times longer service life. Ask for our special booklet on CRYSTOLON "Hot Rods" for all applications.

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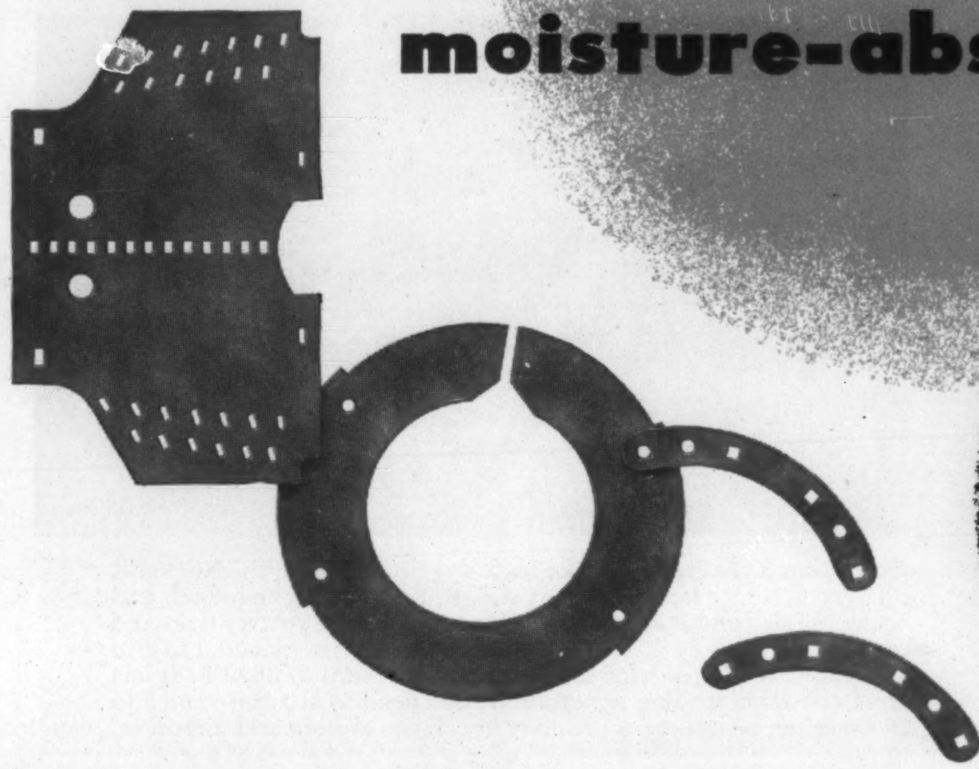
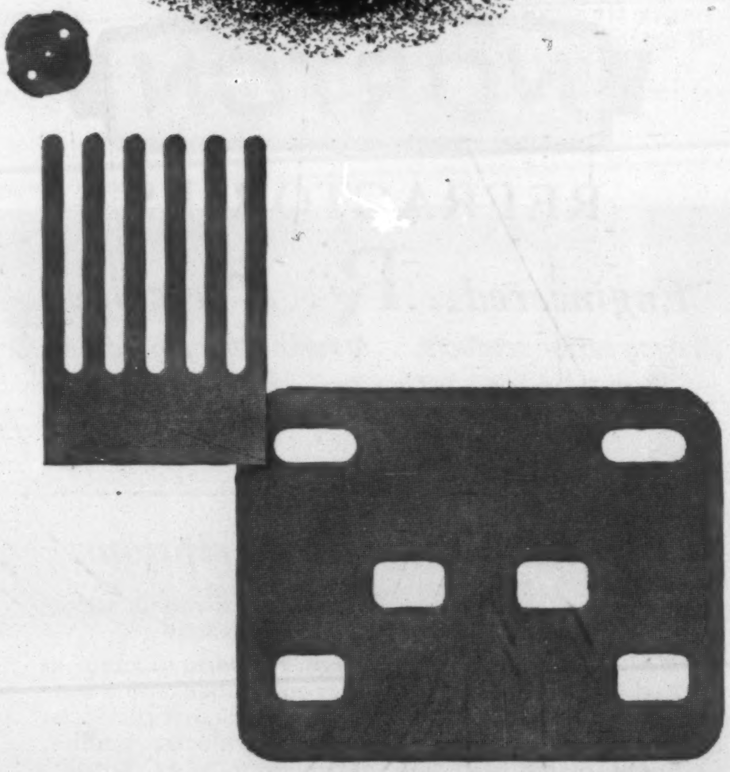
when arc resistance is important . . . and moisture-absorption isn't



ROGERS DUROID 800 CUTS COSTS ON PARTS LIKE THESE



WHY PAY FOR A CHARACTERISTIC YOU DON'T NEED

If moisture pick-up is not critical, DUROID 800 is just as effective an insulating material as higher-priced XP paper-base laminates (which we also make). DUROID 800's arc resistance is better and its tensile and impact strengths are higher. Dielectric strength is excellent when dry. It punches cleanly, takes riveting and can be made flame retardant.

DUROID 800 is listed by the Underwriters Laboratories as suitable for the "sole support of current carrying parts." We suggest that you investigate the possible ways DUROID 800 can help you insulate effectively at reduced cost. Please write Dept. M, Rogers Corporation, Goodyear, Connecticut, for complete technical data and test samples.

Better Parts for Better Products

REINFORCED CHEMICALS

Rogers specializes in combining fibers and chemicals to produce Fiberloys that meet special material requirements. We welcome problems that existing materials can't solve.

ROGERS CORPORATION

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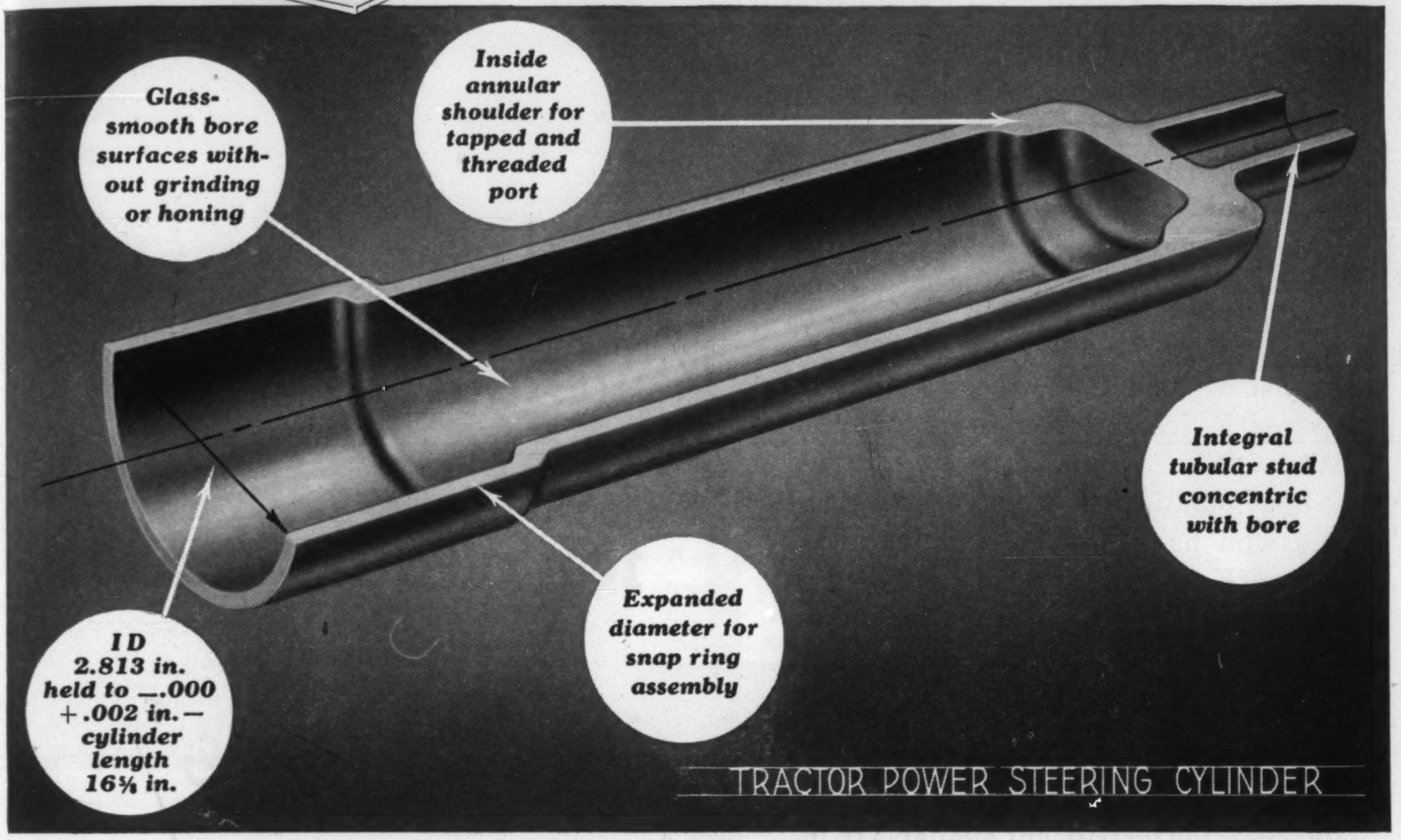
*Now **Mullins Koldflo** makes your dream design **practical***


Glass-smooth bore surfaces without grinding or honing
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ID 2.813 in. held to —.000 +.002 in.—cylinder length 16⅝ in.
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- ***And Mullins Koldflo design cuts your costs***

NOW the designer's "idea horizon" is unlimited! This revolutionary new Mullins *Koldflo* process makes it *simple* and *practical* to design precision parts that were formerly too costly to consider. Call your nearest Mullins office and an experienced Mullins *Koldflo* sales engineer will help you design parts that can be mass produced by the Mullins *Koldflo** process! Write for booklet *"How would you tool-up to make an egg?"*

*Trade-Mark

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Phone—Pennsylvania 6-2773

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Phone—Diamond 1-1490

Chicago
332 South Michigan Avenue
Phone—Harrison 7-3725

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There's a reason . . .

Look at the nameplates on the instruments in your plant . . . and in any other plant you may happen to visit. Chances are you'll find a large percentage of them bear the *ElectroniK* name. For the fact of the matter is that literally thousands of different industrial plants have purchased a total of more than eighty thousand of these instruments in the past fourteen years.

The list of companies who have chosen *ElectroniK* instruments reads like the "Who's Who" of industry. It includes leading manufacturers, large and small alike who have ordered and reordered *ElectroniK* instruments for all types of measuring, recording and controlling assignments.

This widespread acceptance didn't just happen. Some of it is doubtless due to the fact that this was the pioneer electronically operated instrument available to industry on a practical, economical basis. And because it was . . . and is . . . the leader in its field, it has behind it a uniquely broad background of development and application experience. Men in production, engineering, maintenance and research have come to know what this instrument can do, and to rely on it in the most exacting jobs.

Equally important is the excellent record which *ElectroniK* instruments have earned for themselves. They have proved their performance, in sensitivity and precision that set the standard of industry. Their versatility has opened the way to better measurement and control of temperature, flow, pH and dozens of other variables. And their simple, rugged construction has reduced maintenance to a minimum . . . and set records of dependable service under the toughest and dirtiest factory conditions.

Versatility

for commercial

heat-treating . . .

in *ElectroniK*

Catalog 54-1 is a handy reference . . . lists specifications and prices for all ElectroniK control instruments, Pyr-O-Vane millivoltmeter pyrometers, Brown thermometers, and associated safety equipment, valves and accessories. Write for your copy today.

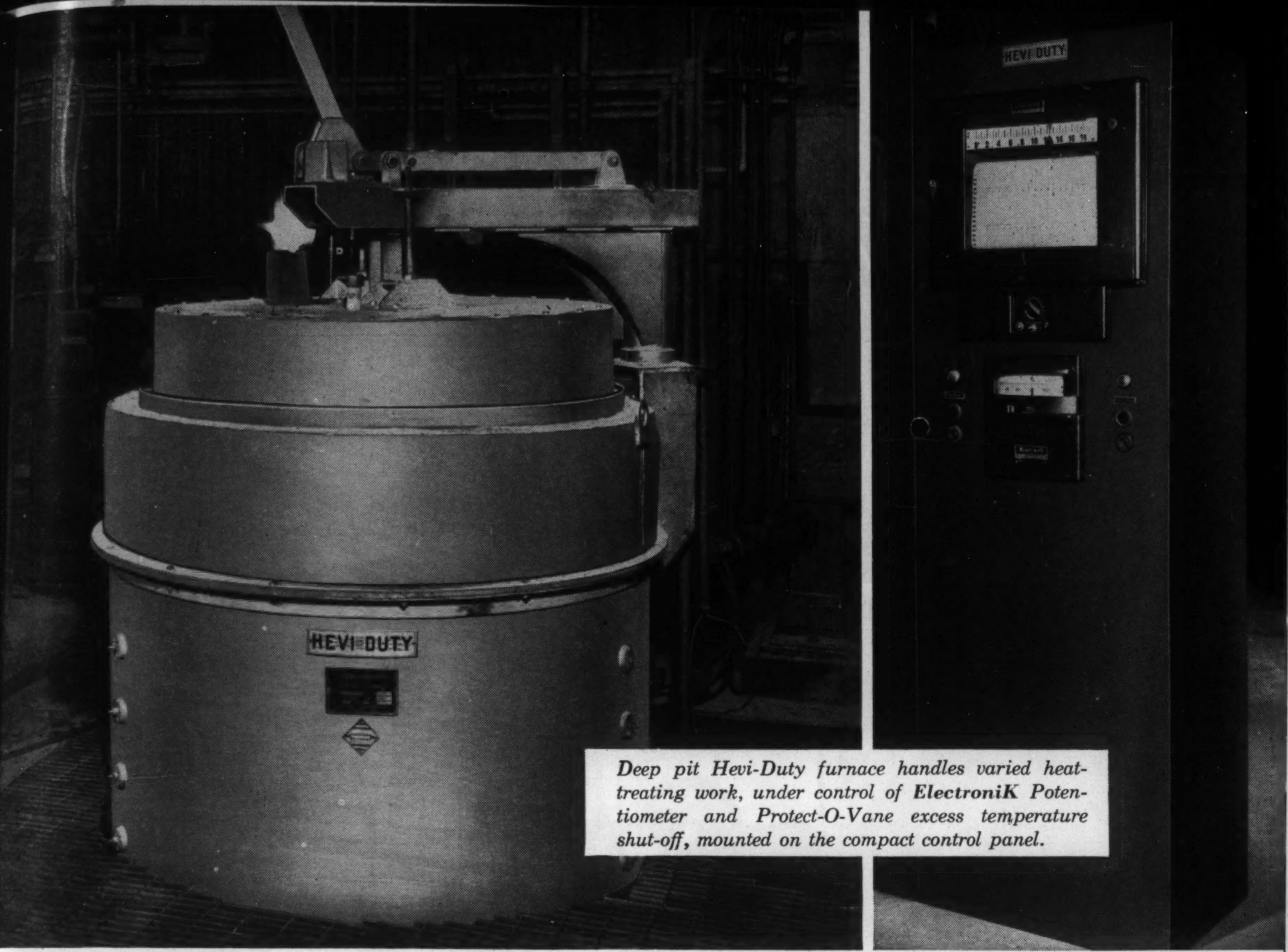
Condensed Catalog and Price List 54-1

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
furnace and oven controls

TEMPERATURE
Controllers · Recorders · Indicators

SAFETY CONTROL EQUIPMENT

CONTENTS



*Deep pit Hevi-Duty furnace handles varied heat-treating work, under control of **ElectroniK** Potentiometer and Protect-O-Vane excess temperature shut-off, mounted on the compact control panel.*

controlled Hevi-Duty furnaces

When every heat-treating job is different—as it is at the California-Doran Heat Treating Company—versatility of equipment really pays dividends. To get the flexibility and accuracy they need for handling diversified production, this big Los Angeles commercial heat-treating firm uses Hevi-Duty furnaces equipped with *ElectroniK* control.

The furnace is a deep pit type which can be used for any temperature from 250 to 1850° F., for tempering, annealing and hardening. And the *ElectroniK* control system which regulates it has ample flexibility to give close temperature tolerances over this entire range. The instrument's *Electr-O-Pulse* control relay provides accurate proportional control of heating power. It switches full input alternately on and off in pulses of variable length, to adjust average power exactly to the value required to hold temperature at the set point . . . for any furnace load, large or small.

ElectroniK controllers are the ideal partner of good furnaces. By the thousands, they have proved their ability to meet the most stringent heat-treating specifications. Be sure to specify them on your new furnaces. Call on your nearby Honeywell sales engineer for a discussion of your own requirements . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO.,
Industrial Division, Wayne and Windrim Avenues,
Philadelphia 44, Pa.

- **REFERENCE DATA: Write for new Furnace and Oven Catalog No. 54-1**

H
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MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls

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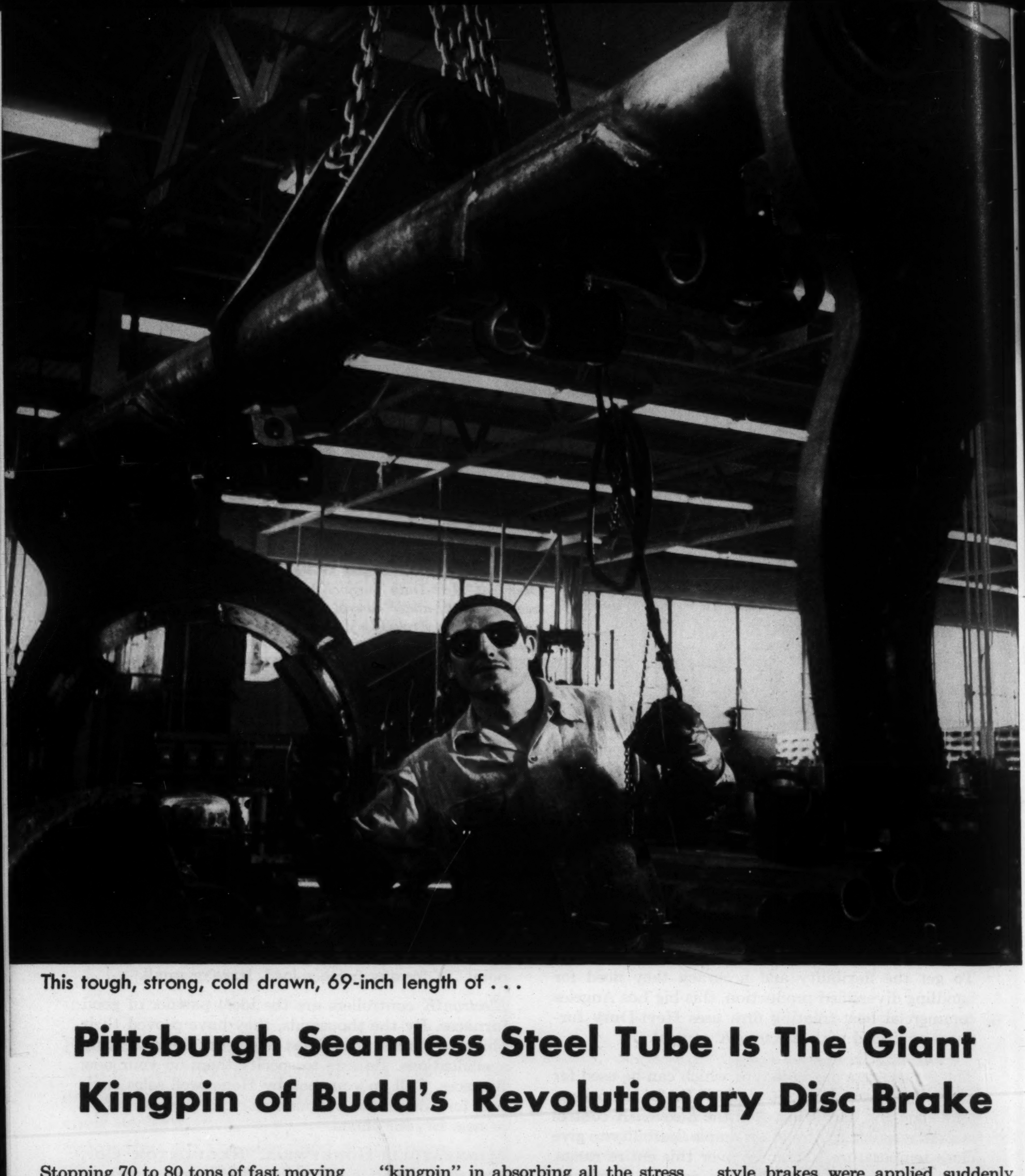

This tough, strong, cold drawn, 69-inch length of . . .

Pittsburgh Seamless Steel Tube Is The Giant Kingpin of Budd's Revolutionary Disc Brake

Stopping 70 to 80 tons of fast moving railroad car safely, quickly and efficiently without pitching passengers out of their seats has long been a goal of railroads and car builders alike. Budd Company, after years of research, came up with the answer in the revolutionary Budd Disc Brake. It is built around a 69-inch length of the finest grade Pittsburgh Seamless Steel Tubing which acts as the giant "kingpin" in absorbing all the stress and strain of the braking reaction.

Here's how it works! Old style brakes had shoes which were applied directly to the wheels' surface. The new Budd Disc Brake has a large, cast iron disc mounted on the inboard side of each wheel. Controlled friction is applied to both sides of these discs by two sets of air operated brake shoes.

Here's the difference! When old style brakes were applied suddenly, passengers were jolted—and damaging heat generated in the wheels. With the Budd brake, wheels do only the jobs they were originally designed to do—support and guide the car along the rails. They do not have to act as brake drums.

Instead the brake drum function has been transferred to the air cooled disc, precisely engineered to do that

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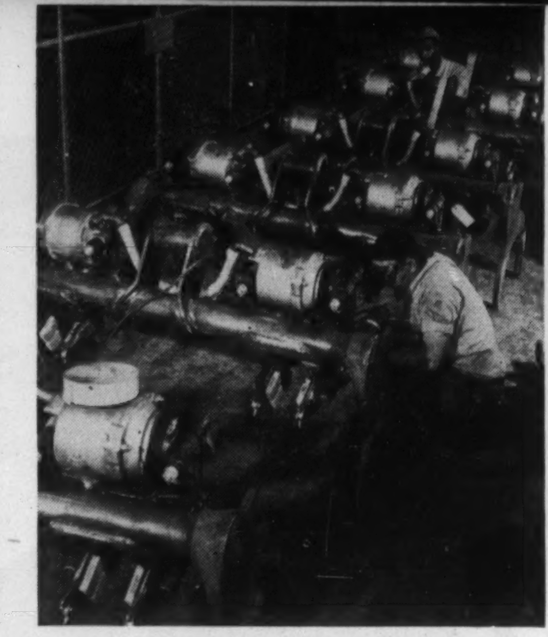
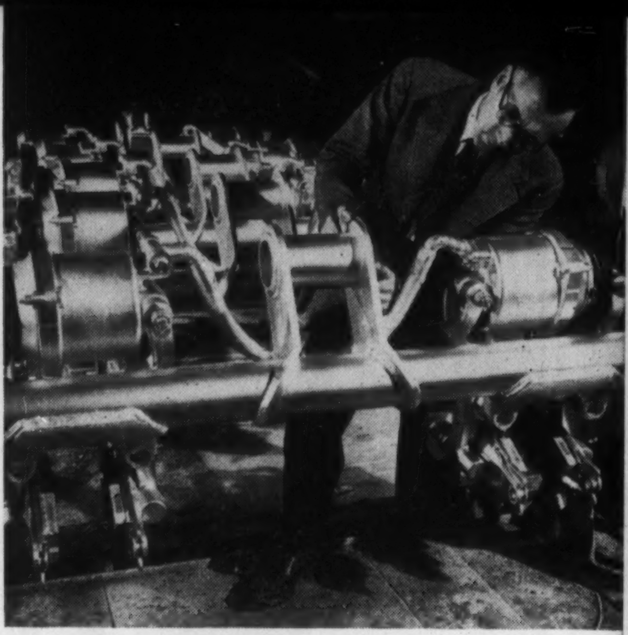
Uniform physicals make possible operations like expanding, welding, and stress relieving of welds at Budd's Red Lion plant near Philadelphia.



The most modern type air cylinders, brake shoes, and other vital parts of the disc brake assembly are installed in this production line . . .



A rigid, final inspection is given the completed brake assembly now aluminum painted and ready for installation on train trucks . . .

important job alone. Stopping is so smooth and chatter-free even under emergency application that passengers are barely aware that the brakes are being applied.

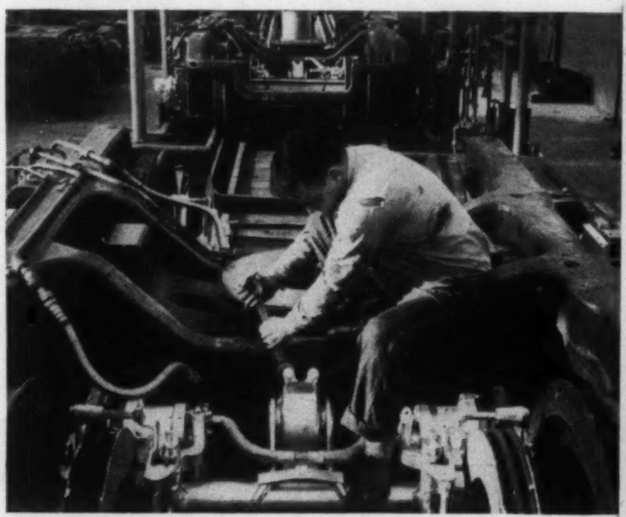
The results are as follows! Because passenger comfort has been increased and maintenance costs reduced, old style brakes are rapidly being replaced by The Budd Company's Disc Brake on America's fastest, most modern trains. Disc brakes are easier to service, cost an average of $1,000 less per car, per year to maintain. They save nearly a ton of dead weight per car, have half as many pins and bushings to service as brakes using the wheel as the brake drum. Brake shoe life is increased 10 to 20 times!

Above all, the Budd Disc Brake is safe. It is standard equipment on Budd's new self-powered, economical Rail Diesel Car (RDC) which is reviving railroad travel in metropolitan areas by greatly reducing operating and maintenance costs.

Inherent quality helps make this possible! Passenger safety and comfort and increased braking efficiency, possible with the new Budd brake, stems from brilliant design engineering and high quality of component parts. For example, Pittsburgh Cold Drawn Seamless Steel Tubing was selected for its high strength-for-weight ratio, for weldability, for close tolerance and smooth surface finish. It provides the giant "kingpin" which has an ultimate strength of 77,000 pounds per square inch—more than enough to absorb the tremendous torsion and bending stresses of the braking reaction.

All of the load of the braking reaction is carried through the "kingpin" seamless steel brake frame tube to the hanger on the railway car truck, and to the outside bearing arms. This application of Pittsburgh Cold Drawn Seamless Tubing is typical of its many vital uses in the aviation, automotive, machine tool, agricultural implement and other industries.

Pittsburgh Seamless Cold Drawn Tubing might be the "kingpin" in reducing costs and improving the products you manufacture. Why not consult a Pittsburgh Steel representative? He may have a suggestion that can save both you and your customers time and money. Write for complete information regarding Pittsburgh Seamless Cold Drawn Tubing.



Four bolts attach the assembly to the hanger box, which is welded to truck . . .

Now installed and ready to roll on one of Budd's self-powered Rail Diesel Cars (RDC), the Budd Disc Brake greatly reduces maintenance costs while improving braking and providing greater passenger comfort.

"Everything New But The Name"

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Zinc alloy castings are stable, strong and rate highest in dimensional accuracy. The remarkably smooth surfaces obtained with zinc alloys in the "as cast" condition, keeps finishing work to a minimum. Frequently, only buffing is necessary prior to plating or for the application of other types of finishes. Due to the high fluidity of zinc alloys at casting temperature, die castings of highly complex design needing little or no machining can be readily produced.

The relative market value of the metals commonly used in die casting is not the only factor in choosing alloys for die castings. Production costs may counteract the difference in the metal cost.

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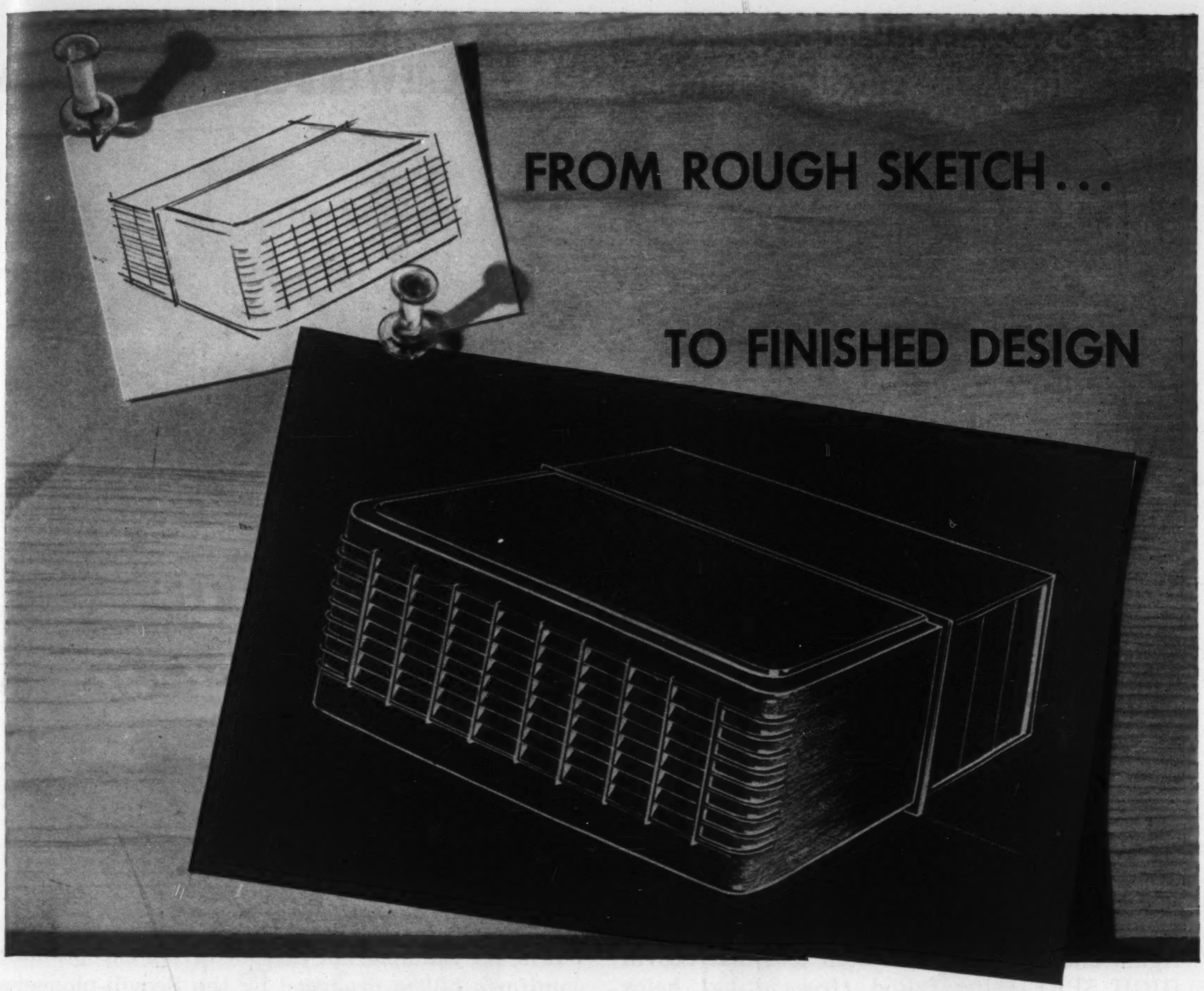

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City, Zone, State

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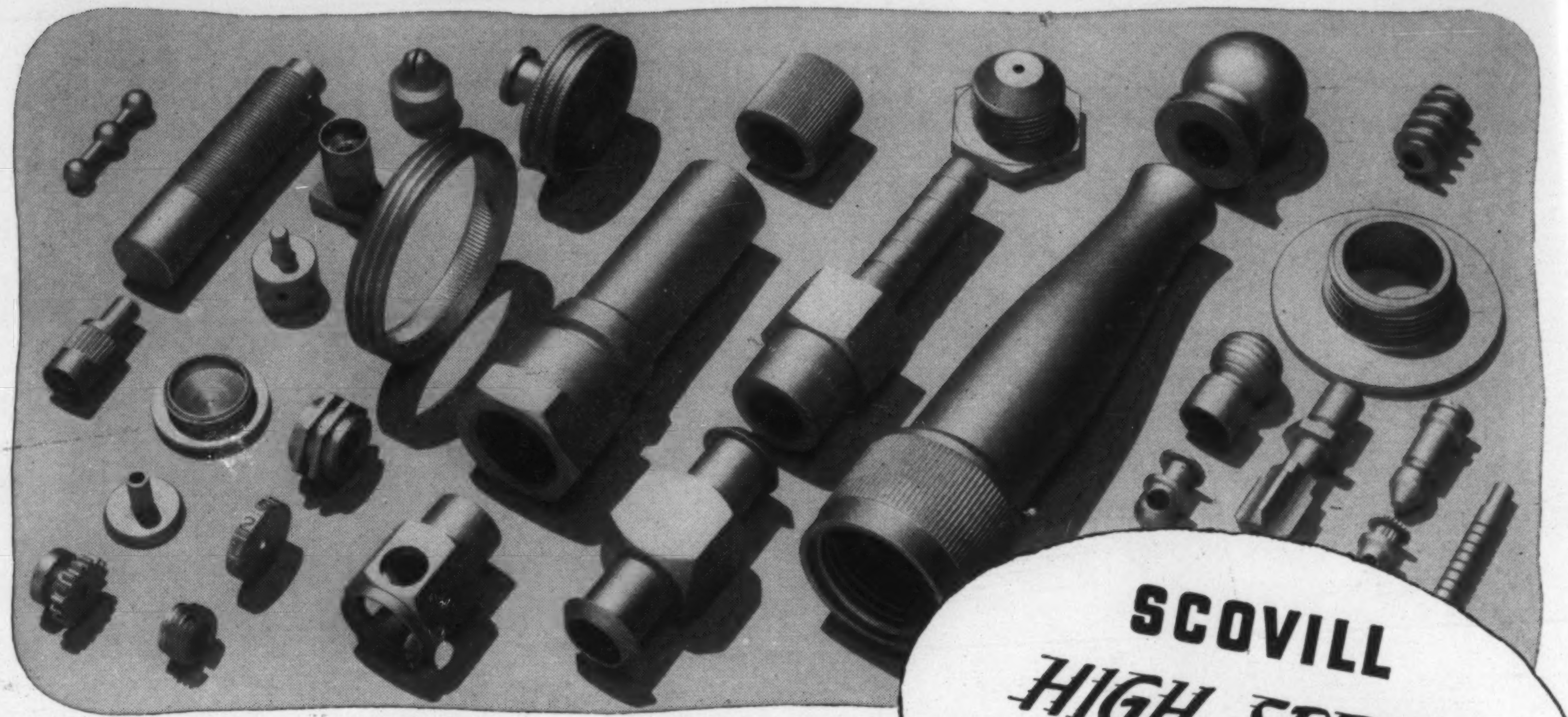

When products like these are made from . . .

SCOVILL
HIGH SPEED
BRASS ROD
(free-cutting)

You Can SELL the Difference . . .

Again and again we have been told that Scovill HIGH SPEED Brass Rod (free-cutting) helps approach realization of seven prime objectives:

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- Maintenance of close tolerances.
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There are many technical reasons for the DIFFERENCE in Scovill HIGH SPEED Brass Rod. It is, for example, hot extruded from exceptionally uniform billets produced by the Scovill-pioneered Continuous Casting Process. Special methods are used to obtain correct temper draw. No matter how much of this fine rod you use, you will find dependably uniform chemical analysis and uniform temper from rod to rod, order to order . . . freedom from extrusion defects . . . smooth, clean burnished surfaces.

Scovill HIGH SPEED Rod is suitable in temper for 99% of screw machine operations, and is stocked for immediate availability at key industry centers. Contact your nearest Scovill Branch Office listed below.

SCOVILL MILL PRODUCTS

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CLEVELAND 2, Ohio
6516 Detroit Avenue

DETROIT 7, Michigan
6460 Kercheval Avenue

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2627 South Soto Street

NEW YORK 17, New York
Chrysler Building East
161 East 42nd Street

PHILADELPHIA 22, Pennsylvania
1419 North Broad Street

PROVIDENCE 3, Rhode Island
183 Public Street

ROCHESTER 6, New York
175 Dodge Street

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GRAMIX® sintered metal parts

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- can be oil impregnated for self-lubrication
- improve product performance

iron brake wheel 60¢
bronze split clamp 11¢ a pair
bronze friction clamp 4¢
iron spring retainer 33¢
iron bearing 1½¢
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bronze check valve seat 13¢
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103

OUR 100th YEAR

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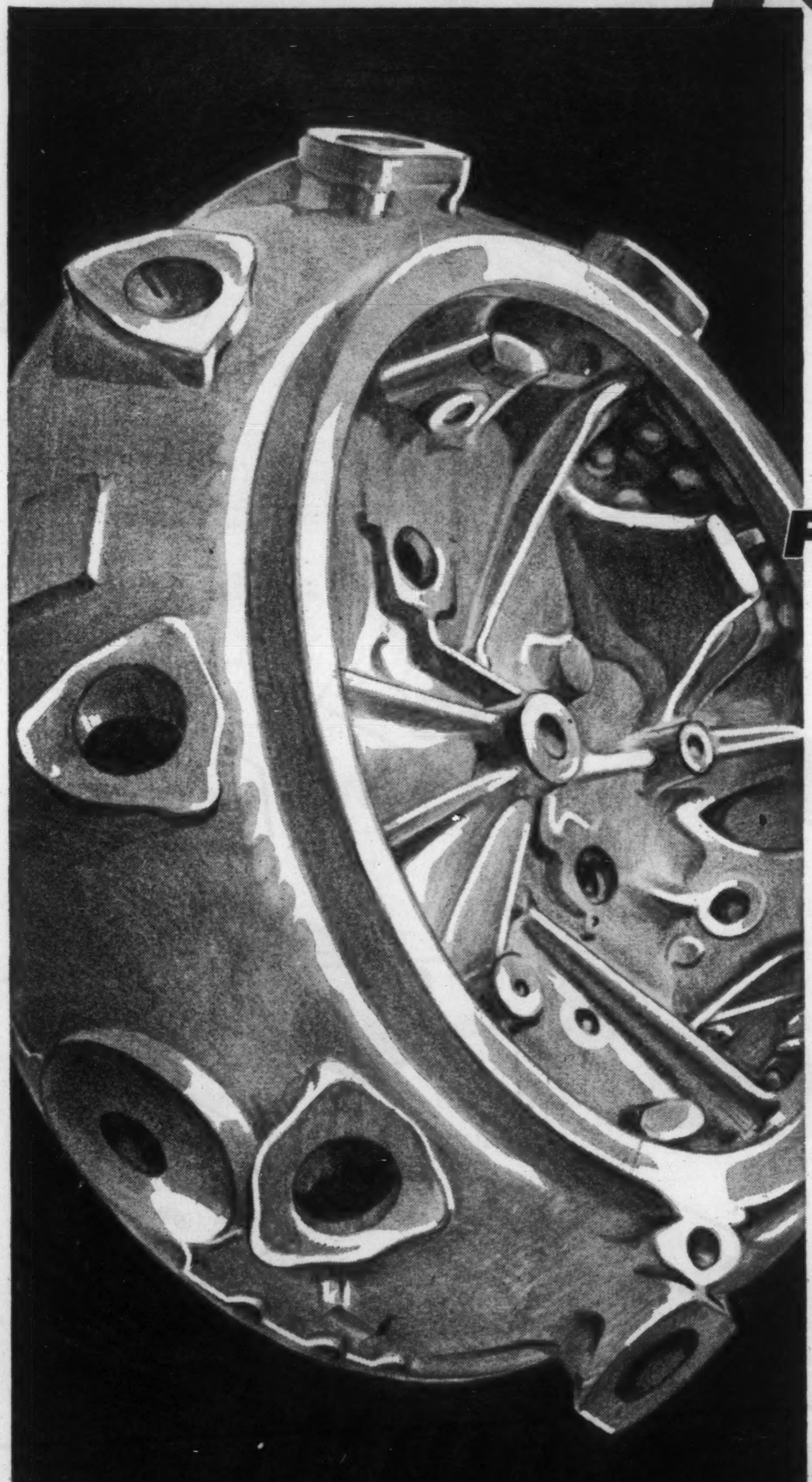
MAGNESIUM AND ALUMINUM CASTINGS BY

ROLLE MAJOR CONTRIBUTOR to AIRCRAFT, RADAR, and ELECTRONICS



FROM small castings up to the largest ever made . . . in magnesium or aluminum . . . for aircraft, radar, and numerous other applications—Rolle can provide you with a complete foundry service. Our engineering and research departments, long experienced in the science of reducing weight with aluminum and magnesium, stand ready to offer you full design and development service at no additional cost. Quality control throughout production, including quantometer analysis, assures that your specifications will be reliably met. Write for our free brochure that shows you how to . . . **FIGHT WEIGHT WITH STRENGTH WITH ROLLE**

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301 Cannon Ave. • Lansdale, Pa.

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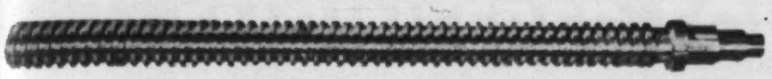
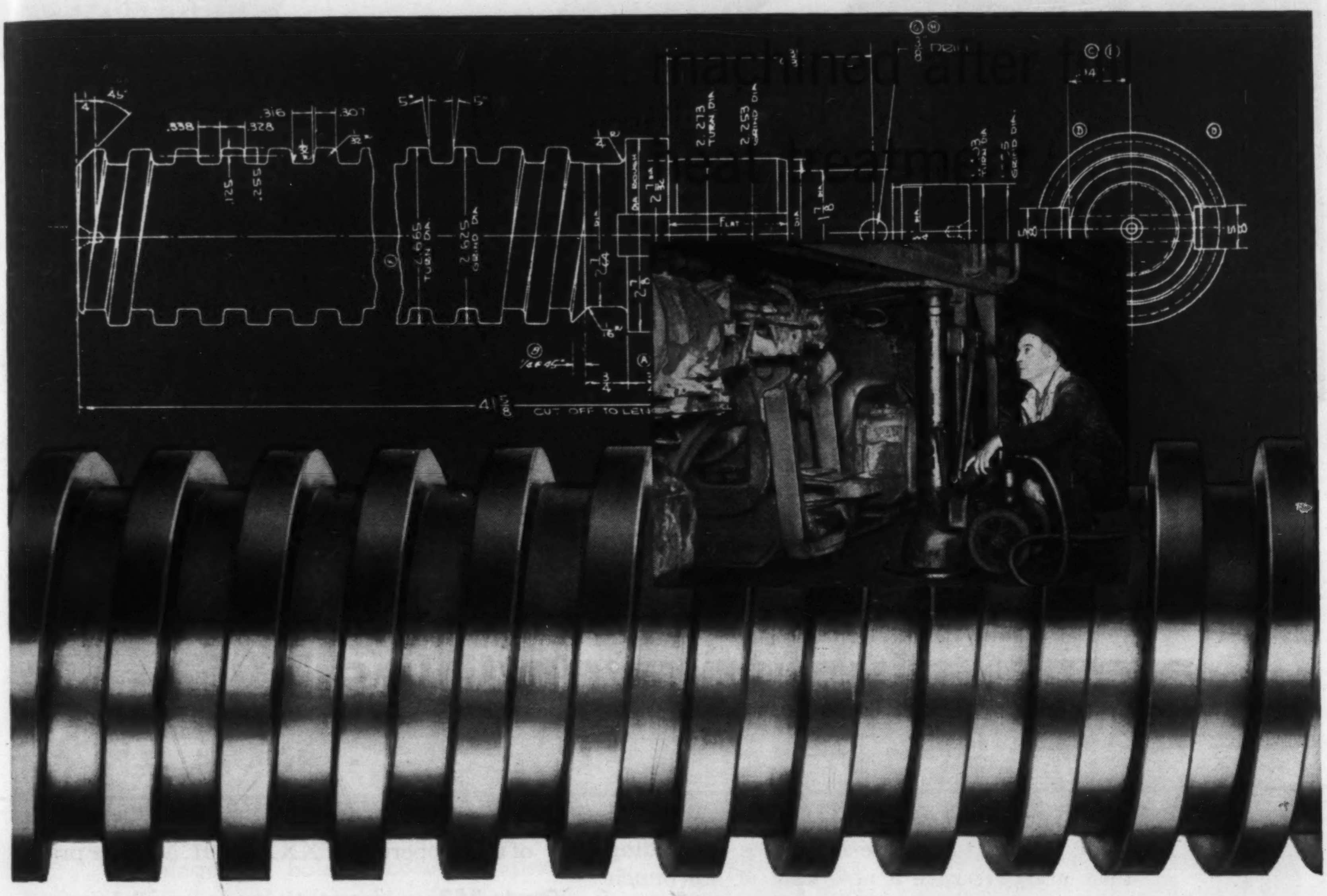


MAX-EL alloy steel part for 100-ton jack machined after full heat treatment



The Max-el part shown above is the lifting screw from a Duff-Norton air motor screw jack. It's the part that actually lifts and holds the load . . . up to 100 tons.

To make the part, blanks are cut from Max-el 3½ bar stock. After heat treating to 321-341 Brinell, threads are chased and all machining performed. Max-el's optimum machinability after heat treatment, its high-strength, toughness, deep hardenability — which prevents thread sinkage, and high surface finish make it an ideal choice for this rugged application.

But try Max-el yourself. Its excellent machinability means longer tool life, more pieces per grind. And you'll appreciate its freedom from distortion and superior quality. For immediate delivery of Max-el call your nearest Crucible representative.

Join your Civil Defense Team NOW!

CRUCIBLE first name in special purpose steels

54 *years of* *Fine* *steelmaking* **ALLOY STEELS**

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

Branch Offices and Warehouses: ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DAYTON DENVER • DETROIT • HOUSTON • INDIANAPOLIS • LOS ANGELES • MILWAUKEE • NEWARK • NEW HAVEN • NEW YORK • PHILADELPHIA • PITTSBURGH PROVIDENCE • ROCKFORD • SAN FRANCISCO • SEATTLE • SPRINGFIELD, MASS. • ST. LOUIS • ST. PAUL • SYRACUSE • TORONTO, ONT. • WASHINGTON, D. C.

For more information, turn to Reader Service Card, Circle No. 307

New Taylor laminates

are premium in everything but price

YOU'LL LIKE everything about this new family of Taylor paper-base laminates—including their price. They're a new kind of hot-punch laminate, uniform all the way through, with no surface overlay of resin.

In insulation resistance, water absorption, power factor, flame retardance and dimensional stability, they'll meet or exceed your strictest specifications. And they punch and stake so well . . . with smooth surfaces and clean edges . . . that you can produce complex parts with maximum utilization of each sheet.

Four different grades are available in production quantities, in standard sheet size of approximately 49″ by 49″:

XXXP-301 . . . *the top grade laminate* with unusually high insulation resistance, lowest water absorption . . . excellent punching and staking.

XXP-351 . . . a high grade laminate with most of the properties of XXXP-301, at lower price.

Grade 353 . . . a quality grade laminate priced for economy, with outstanding electrical and physical properties.

Grade 354 . . . an easily fabricated grade having low water absorption and good stability . . . priced for real savings.

Taylor Fibre Co. Plants in Norristown, Pa.; and La Verne, Calif. *Branch offices in Atlanta; Boston; Chicago; Cleveland; Dayton; Detroit; Indianapolis; Los Angeles; Milwaukee; New York City; Philadelphia; Rochester; San Francisco; St. Louis; and Tolland, Connecticut. Distributors in Grand Prairie and Houston, Texas; Jacksonville, Florida; New Orleans, Louisiana; and Toronto, Ontario.*

WRITE TODAY FOR FULL SPECIFICATIONS, AND FOR ENGINEERING ASSISTANCE IN APPLICATION

TAYLOR
Laminated Plastics
Vulcanized Fibre

For more information, turn to Reader Service Card, Circle No. 452

Case History M M-110

Here's what we mean by SUPERIOR ENGINEERED FOUNDRY PRODUCTS...

PROBLEM:

1. This part for an assembly line conveyor was not being produced economically as a weldment.
2. The part must withstand constant shock and rough handling of the upper hinge member.

SOLUTION:

The proven principles of SUPERIOR ENGINEERED FOUNDRY DESIGN were applied in redesigning the part instead of merely duplicating the original weldment design as a steel casting. Machining of the part was done by Superior's machine shop.

RESULT:

50.2% SAVINGS

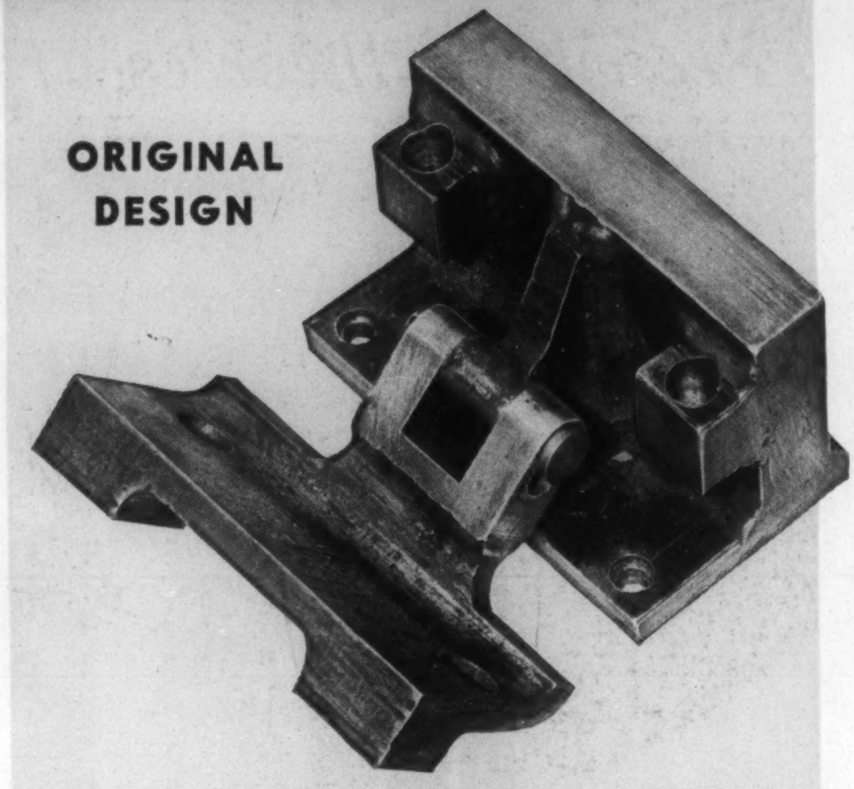
1. The steel casting costs less to produce and less machining is required because the hinge pin hole is cored. Superior delivers complete, machined units, ready for installation.
2. The part has the steel casting's inherent strength for continuous hard use plus a weight reduction of 7.2%.

Total Cost of Part Reduced 50.2%.

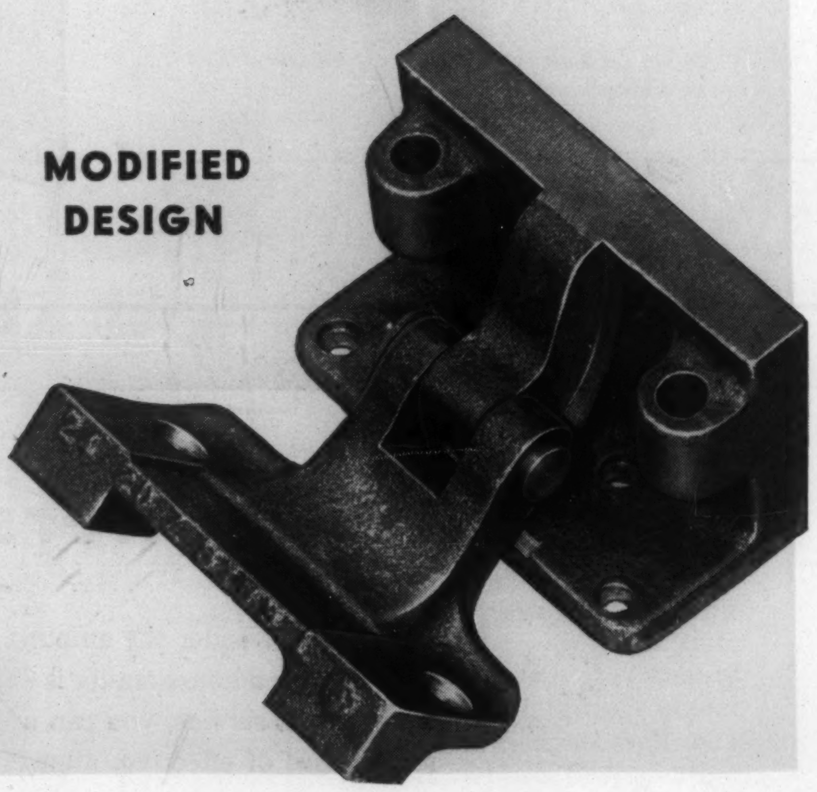
YOU, TOO, CAN GET SAVINGS LIKE THESE BY CONSULTING SUPERIOR'S PRODUCT DEVELOPMENT SERVICE.

Remember...you benefit through correct design. If it can be cast, Superior's service develops the best design in which to cast it. If it shouldn't be cast, Superior's service develops the reasons why.

ORIGINAL DESIGN



MODIFIED DESIGN



Courtesy of Fabricated Steel Products of Indiana, Inc.

Make your parts Superior Engineered Foundry Products . . . steel castings to 30,000 pounds . . . malleable iron castings to 300 pounds.

Have you entered the first annual Product Development Contest sponsored by the Steel Founders Society of America? We'll be happy to send you details. Just drop us a line.

SALES OFFICES:

CHICAGO 4, Railroad & Industrial Products Co., 332 S. Mich. Ave.
DETROIT 7, Sales Engineering Corporation, 955 E. Jefferson Ave.
BUFFALO 21, Gibney-Decot Corporation, 2107 Kensington Ave.
CLEVELAND 14, C. A. Lapp & Co., 1404 East 9th Street

ENGINEERED FOUNDRY PRODUCTS

SUPERIOR STEEL AND MALLEABLE CASTINGS CO.

BENTON HARBOR, MICHIGAN, U.S.A.

Making Good Castings for Quality-Conscious People Since 1916

For more information, turn to Reader Service Card, Circle No. 305

See what adhesives are doing today!

Sealing trailers at the seams

When you consider the amount of weathering to which a house trailer is exposed in the course of its service, you can appreciate the importance of effective, all-around sealing.

3M
COMPANY

Finding a seal to keep out dust, weather and noise used to present a real problem. But it doesn't any longer—thanks to 3M's new ribbon-like sealer, EC-1202. Made of synthetic rubber, EC-1202 is extremely flexible and easy to handle. And it's reinforced with sturdy fabric so that it holds its dimensions and is exceptionally easy to apply.

On trailers, like the one pictured above, EC-1202 is used to seal metal corners and edges. Next, an extruded aluminum corner is bolted over it for extra protection, to provide a complete seal against weathering of all sorts.

See what adhesives can do for you . . . You can use EC-1202 wherever metal corners, edges, or faying surfaces need sealing. Your 3M sales engineer will give you all the facts on this and other 3M adhesives developed for industry. Call him, or write today for free informative booklet—to 3M, Dept. 66, 417 Piquette Ave., Detroit 2, Mich.

see our catalog in
PRODUCT DESIGN FILE
or write for copy

ADHESIVES AND COATINGS DIVISION **MINNESOTA MINING AND MANUFACTURING COMPANY**

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 122 E. 42 ST., N. Y. 17, N. Y. • CANADA: LONDON, ONT.

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For more information, turn to Reader Service Card, Circle No. 420

When it comes to
light metal alloy and
plaster mold castings . . .

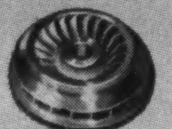
ECLIPSE-PIONEER FOUNDRIES

save you time and money two ways!

1

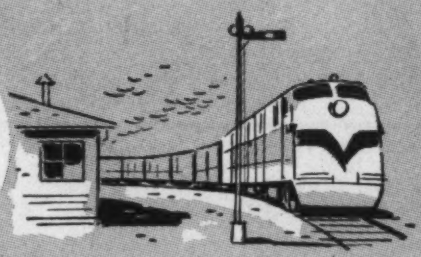
You get better quality castings

If you use aluminum or magnesium alloy or plaster mold castings, you'll be ahead to bring your needs to Eclipse-Pioneer. Our experience of over 20 years in these specialized fields . . . plus infinite care and skill in every step of production from design to final inspection . . . assures you of utmost quality. Due to our high standards of precision, you'll find that Eclipse-Pioneer castings, including those of newly developed Cerium and Zirconium magnesium alloys, can be used with a minimum of machining. This is typical of how Eclipse-Pioneer quality saves you time and money.



Precision (±.005") plaster mold castings

2



You get faster service

The finest methods and equipment, including a completely conveyorized production line, are back of Eclipse-Pioneer's higher quality and better service. Back of it, too, are expert technicians and metallurgists, as well as a skilled research staff whose never-ending job is to seek out new and faster ways of turning out still higher quality castings.

Get in touch with us today

To find out what specific savings we can make for you, write us now at the address below.

FREE! "BOOK OF FACTS"

Please send me your "Book of Facts" on magnesium and aluminum castings.

*Name*__________ *Title*__________

*Company*__________ *Street*__________

*City*__________ *Zone*____ *State*____

ECLIPSE-PIONEER DIVISION FOUNDRIES

TETERBORO, NEW JERSEY

Bendix
AVIATION CORPORATION

Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, New York

For more information, turn to Reader Service Card, Circle No. 413

Announcing

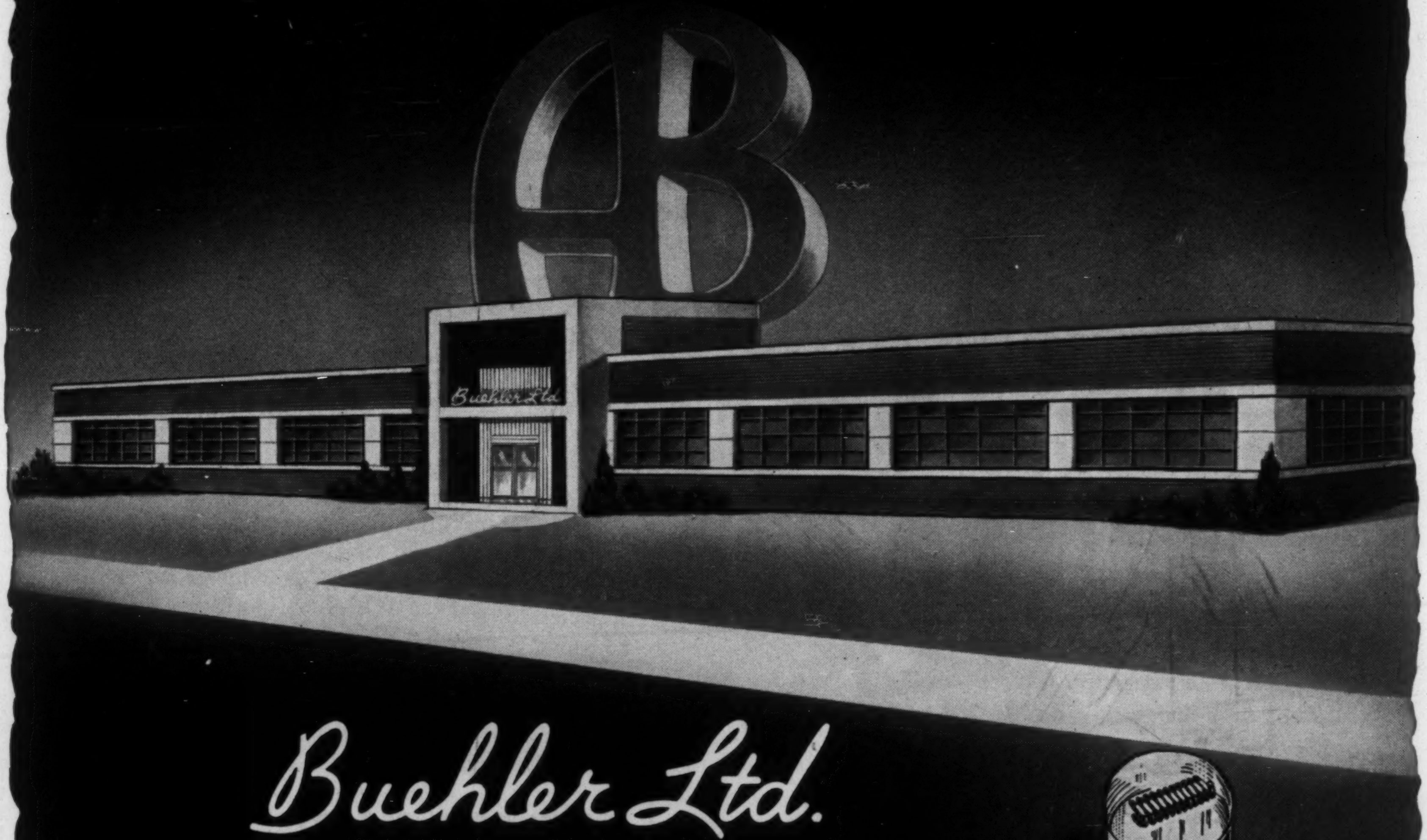
THE OPENING OF OUR NEW PLANT AT

2120 Greenwood at Hartrey Ave., Evanston, Ill.

JUST ONE BLOCK NORTH OF DEMPSTER STREET

These facilities have been arranged so that we can provide better equipment and better service for our customers. Changing your records now to show our new address may prevent annoying delays on future correspondence and orders.

We are delighted with the new building and location and will be pleased if you will take the next opportunity to visit us. A display will be available of our complete line of metallurgical sample preparation equipment, optical instruments for the laboratory, Amsler and Chevenard testing machines and other items.

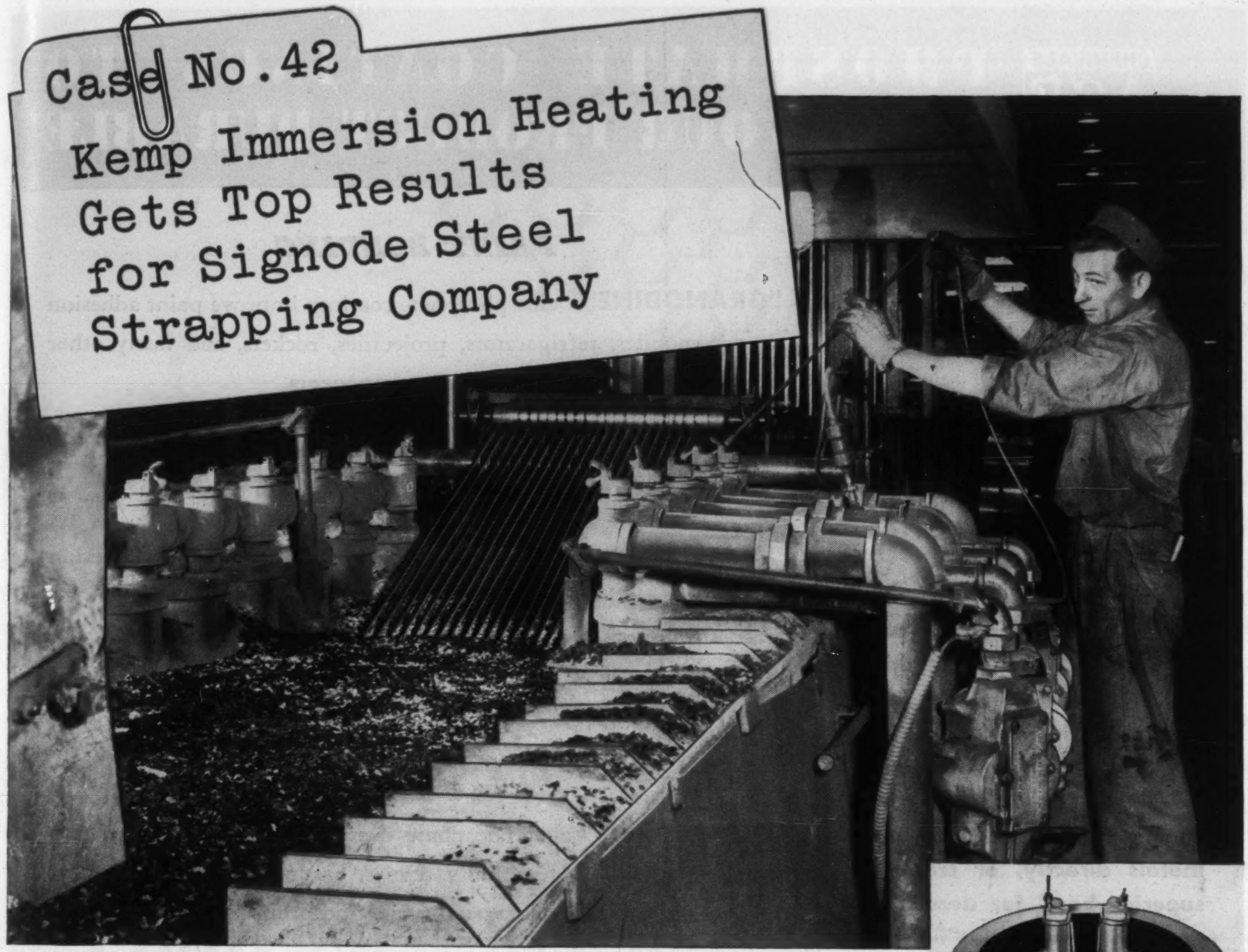

Buehler Ltd.

Buehler Ltd.

METALLURGICAL APPARATUS

2120 GREENWOOD at Hartrey Ave., EVANSTON, ILL., U. S. A.
TELEPHONES: SHeldrake 3-1717 and DAvis 8-3032

For more information, turn to Reader Service Card, Circle No. 311



Case No. 42 Kemp Immersion Heating Gets Top Results for Signode Steel Strapping Company

How Signode Steel Strapping Co. tempers 650 feet of steel strap every minute

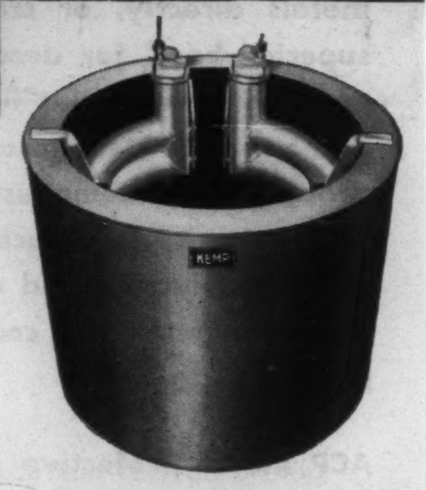
At the Signode plant in Sparrows Point, Md., turning out up to a thousand miles of steel strap daily calls for fast, efficient production line techniques. One highly important phase in the final processing is the tempering bath. Here, Signode called on Kemp Engineers to supply the 15 ton, gas-operated Immersion Melting Pot shown above. Now steel strap is uniformly tempered at the rate of 650 feet per minute.

Kemp Offers More Advantages

By installing Kemp Immersion Heating, Signode benefits in many ways. Unlike underfired pots, Kemp pots are *not* subject to *periodic* and expensive shutdowns . . . won't crack or break. They operate *continuously* at maximum heating efficiency with a *substantial* savings in fuel costs. Offer a greater heating surface, faster heat recovery, lower dross formation, even lower room temperatures. At the same time, this Kemp unit enables Signode to eliminate costly temperature override and open flame fire hazards.

Let Kemp Solve Your Problems

These same advantages apply to all types of melting or heating operations. Whether you are engaged in tempering, annealing, descaling, coating, etc., you can rely on Kemp Immersion Heating. Why not find out how Kemp Engineers can help you, save you money?



This 10 ton oval pot is typical of the many Kemp installations now in use. Features Kemp Carburetor, part of all Kemp equipment, to deliver complete combustion . . . without waste . . . without tinkering. One-pipe air and fuel feed reduces installation costs, simplifies maintenance.

***For more complete facts and technical information, write for Bulletin IE 11 to:* C. M. KEMP MFG.CO., 405 East Oliver St., Baltimore 2, Maryland.**

KEMP OF BALTIMORE

IMMERSION MELTING POTS

CARBURETORS • BURNERS • FIRE CHECKS
ATMOSPHERE & INERT GAS GENERATORS
ADSORPTIVE DRYERS • SINGEING EQUIPMENT

For more information, turn to Reader Service Card, Circle No. 360

CHEMICALS
ACP
PROCESSES

PHOSPHATE COATINGS TO MAKE YOUR PRODUCT DURABLE*

PIONEERING RESEARCH AND DEVELOPMENT SINCE 1914

For more than a third of a century, ACP research chemists and ACP technical representatives in the field have pioneered in the science of metal preservation. They have developed surface treating chemicals which either protect metals directly, or create a superior bond for decorative and protective paint finishes, and now, ACP chemicals and processes are being used the world around to reduce costs, speed production and add to the life-span of countless products.

ACP metal protective chemicals include: protective coating chemicals for steel, zinc and aluminum; metal cleaners and rust removers; final rinse controls; pickling acid inhibitors; copper coating chemicals; soldering fluxes; alkali cleaners and addition agents; copper stripping and brightening solutions.

PAINT BONDING

"GRANODINE"® zinc phosphate coatings improve paint adhesion on automobiles, refrigerators, projectiles, rockets, and many other steel and iron fabricated units or components.

"LITHOFORM"® zinc phosphate coatings, make paint stick to galvanized iron and other zinc and cadmium surfaces.

"ALODINE"® protective coatings provide improved paint adhesion and high corrosion-resistance for aircraft and aircraft parts, awnings, wall tile, signs, bazookas, and many other products made of aluminum.

RUST PROOFING

"PERMADINE"® zinc phosphate coatings provide rust and corrosion proofing for nuts, bolts, screws, hardware, tools, guns, cartridge clips, and many other industrial and ordnance items.

PROTECTION FOR FRICTION SURFACES

"THERMOIL GRANODINE"® manganese-iron phosphate coatings provide both rust proofing and wear resistance — anti-galling, safe break-in, friction on rubbing parts.

IMPROVED DRAWING AND COLD FORMING

"GRANODRAW"® zinc phosphate coatings make possible improved drawing, cold forming and extrusion on such steel products as sheets for stamping, bumpers, parts to be formed, prior to plating or painting, cartridge cases, etc.

**Made, Sold, and Serviced By A Pioneer In Protective Coatings For Metals . . .*

AMERICAN CHEMICAL PAINT COMPANY

General Offices: Ambler, Penna.

Detroit, Michigan ***Niles, California*** ***Windsor, Ontario***

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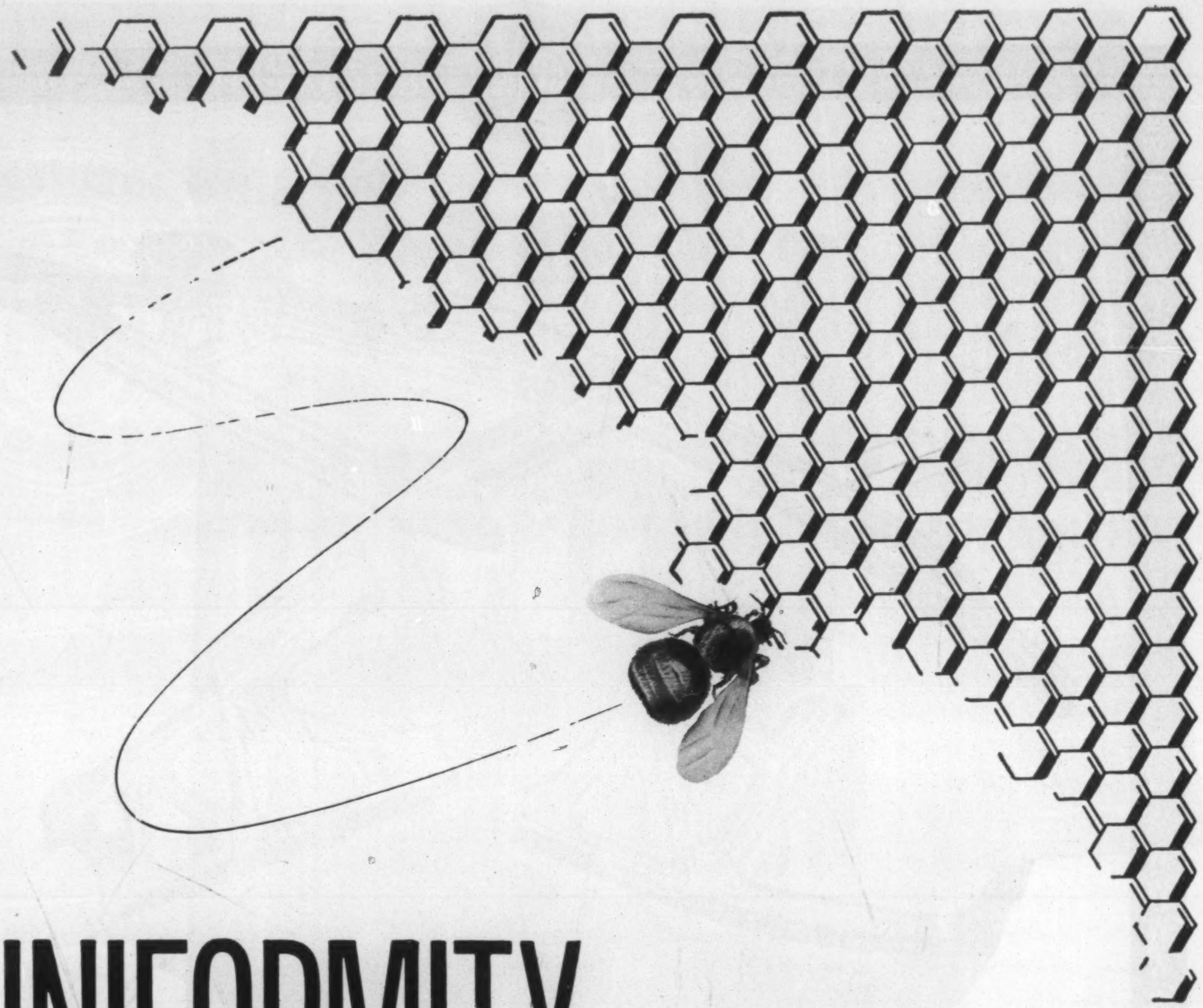

UNIFORMITY

is important

When uniformity is important, specify Bishop because you can rely on Bishop craftsmanship to insure you more uniform small diameter stainless steel tubing (.008″ to 1″ O.D.).

Yes, Bishop, master craftsmen of precious metals since 1842, has proudly made a habit of careful craftsmanship. Now, 112 years later, this priceless ingredient has become our way of life that assures you uniformity in every inch of tubing. It is based on the old fashioned belief that quality of product is its own best salesman.

Next time, particularly when uniformity is important, specify Bishop and be sure! Catalog on request.

When you require stainless steel fabricated tubular parts, investigate Bishop's low cost "under-one-roof" drawing and fabricating facilities.

J. BISHOP & CO. Platinum Works
Stainless Steel Division • Malvern, Pennsylvania

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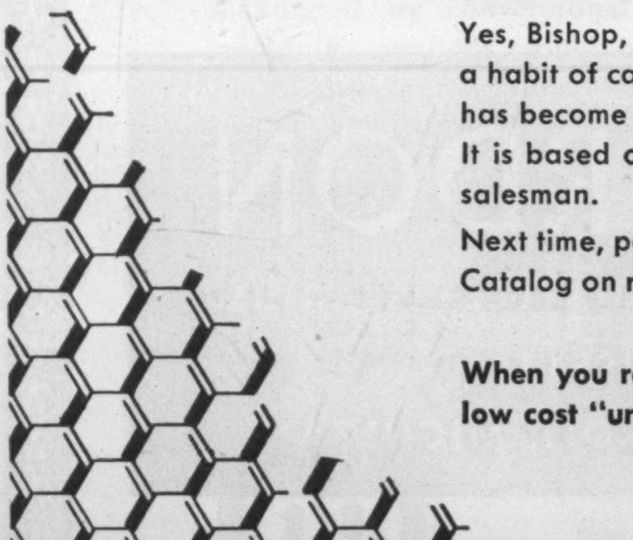

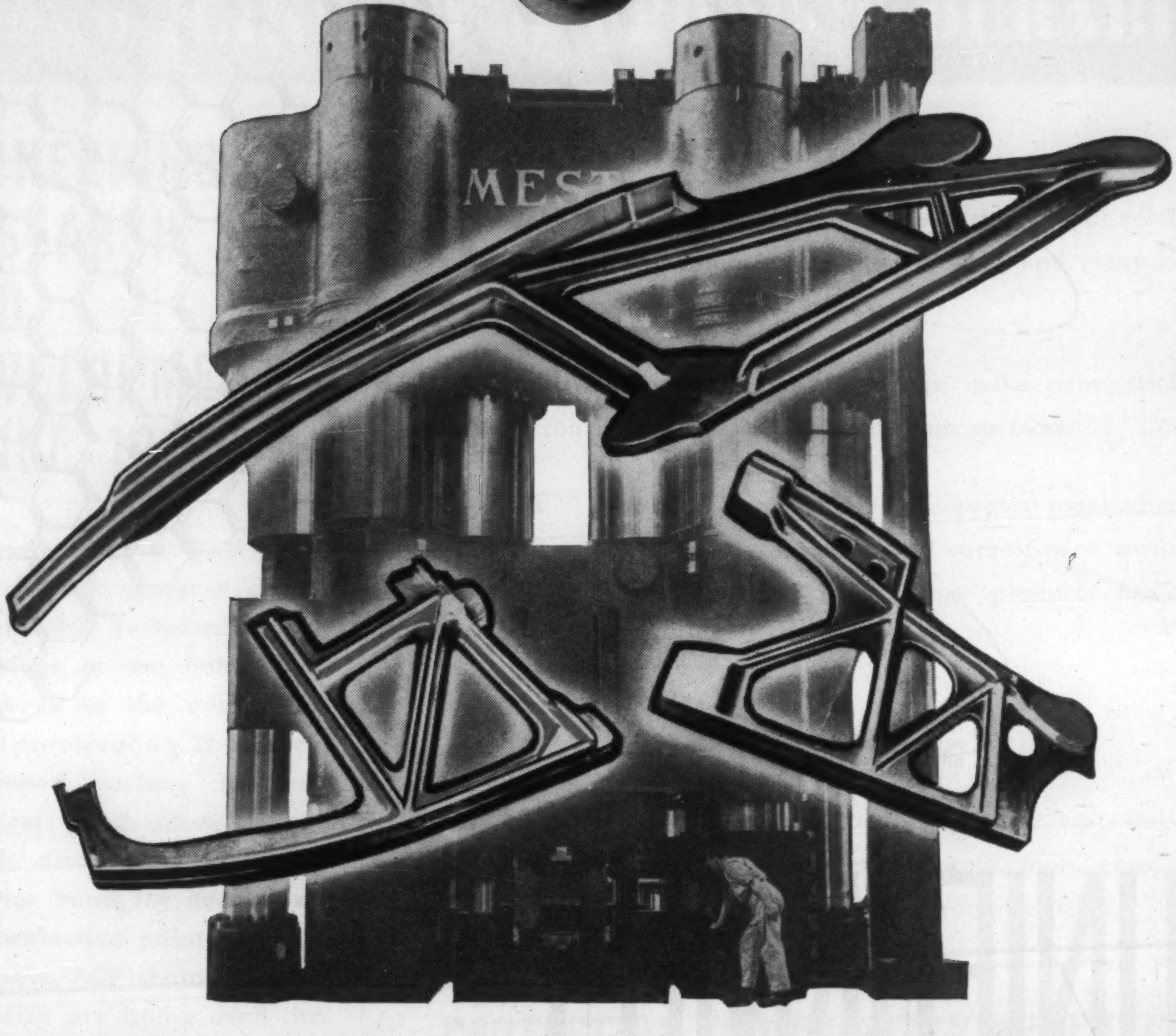

Greater Size and Speed in Aircraft have created engineering problems, the solution of which has required larger and larger forgings of high-strength aluminum alloy. *Examples* shown above are forged structural members used in a modern military bomber, the largest more than seven feet over all. These are forged on an 18,000 ton press, the biggest ever built in this country.

Wyman-Gordon Experience—the most extensive in the industry—is keeping abreast of new forging demands involving the use of Steel, Aluminum, Magnesium, High Density Alloys and Titanium.

• • •

Standard of the Industry for
More than Seventy Years

WYMAN-GORDON

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM
WORCESTER, MASSACHUSETTS
HARVEY, ILLINOIS DETROIT, MICHIGAN

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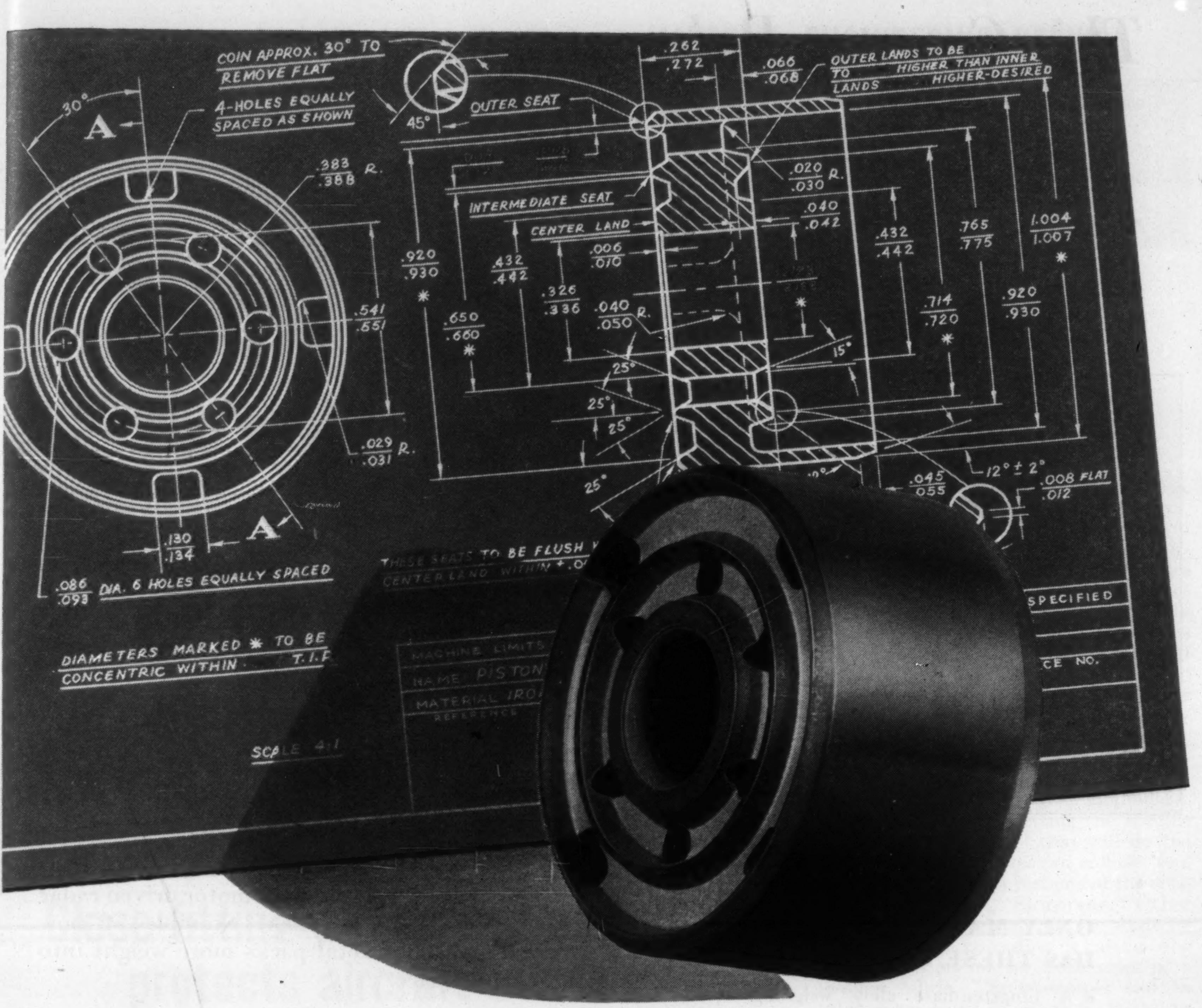
COIN APPROX. 30° TO REMOVE FLAT
4-HOLES EQUALLY SPACED AS SHOWN
30°
A
45°
OUTER SEAT
.262
.272
.066
.068
OUTER LANDS TO BE TO HIGHER THAN INNER LANDS HIGHER-DESIRED
.383
.388 R.
.020
.030 R.
INTERMEDIATE SEAT
.040
.042
CENTER LAND
.432
.442
.765
.775
1.004
1.007
.006
.010
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.008 FLAT
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A
THESE SEATS TO BE FLUSH
CENTER LAND WITHIN
.086
.093 DIA. 6 HOLES EQUALLY SPACED
SPECIFIED
DIAMETERS MARKED * TO BE CONCENTRIC WITHIN T.I.R.
MACHINE LIMITS
NAME PISTON
MATERIAL IRON
REFERENCE
CE NO.
SCALE 4:1

MORAINE MAKES MANY COMPLEX PARTS IN ONE OPERATION

A design can be so complex that the cost of making it by conventional casting and machining methods would be prohibitive. Yet, that same design can be produced by the Moraine metal powder process at moderate cost—usually in one press operation—with no drop-off in quality or precision.

For example, this part, of intricate design and close tolerances, is made in quantity every day at Moraine with very noticeable savings to the customer. It illustrates how much can be done to improve performance and cut costs when customer and Moraine cooperate to adapt part to process.

Moraine's experience with powder metallurgy is extensive and the possibilities it offers to modern industry are almost limitless. There are very few design ideas that cannot be profitably converted into practical parts by the Moraine metal powder process.

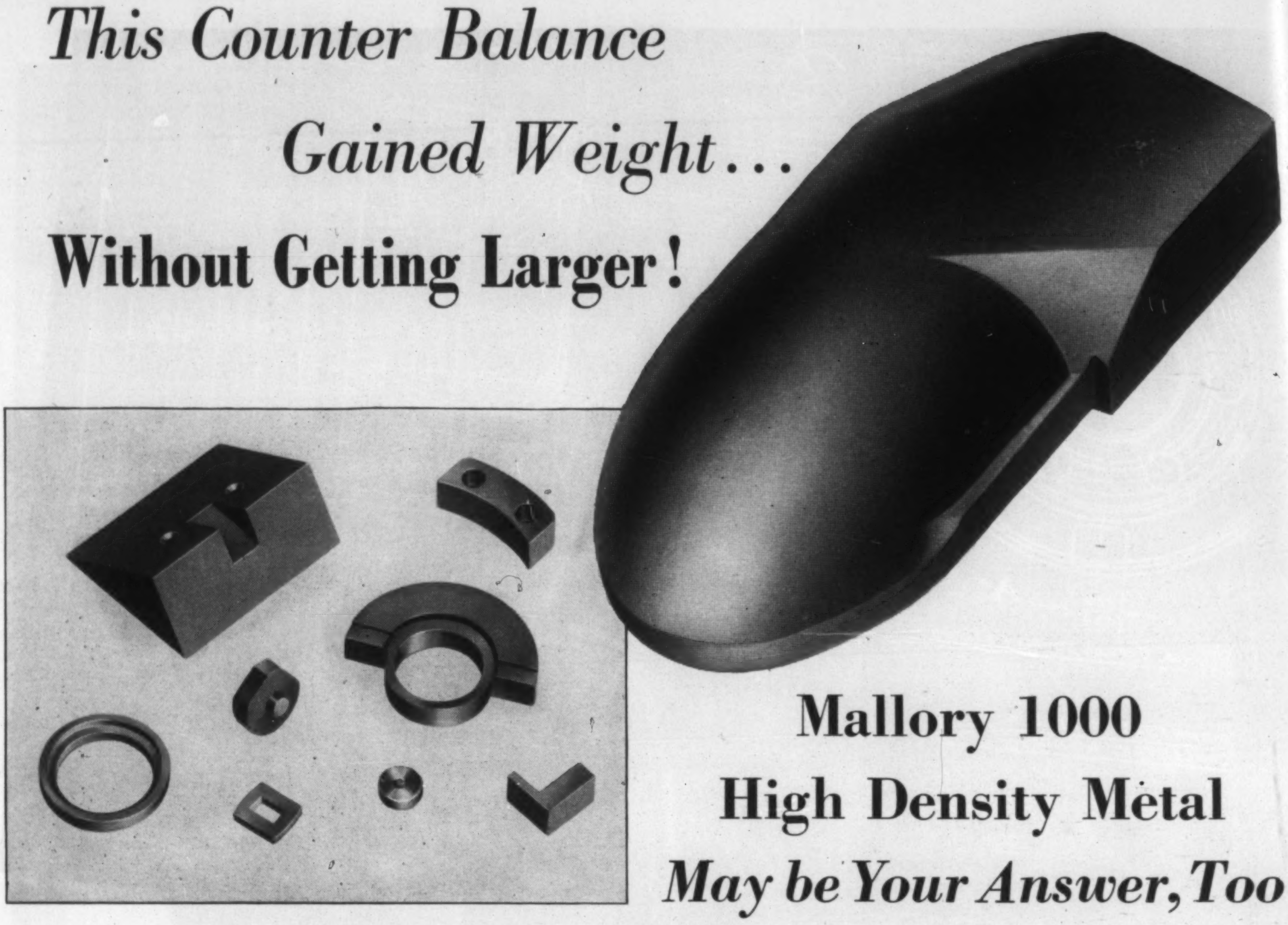
m

moraine products

DIVISION OF GENERAL MOTORS CORPORATION, DAYTON, OHIO

METAL POWDER PARTS

This Counter Balance Gained Weight... Without Getting Larger!



Mallory 1000 High Density Metal

May be Your Answer, Too

ONLY MALLORY 1000 METAL HAS THESE CHARACTERISTICS

- A tungsten-base alloy weighing 16.96 grams per cubic centimeter.
- High tensile strength . . . 105,000 lb. per square inch.
- High modulus of elasticity. No objectional drift at rotational speeds as high as 40,000 rpm.
- Excellent machinability. Surface finishes from 10 to 40 microinches, depending on method. Performance and chip form similar to gray iron.

Mallory 1000 is also highly effective as a radiation shielding material.

This counter balance for a motor driven radar antenna is an excellent example of how Mallory 1000 Metal packs more weight into a given space.

With a density more than twice that of steel or brass, with far greater strength than lead, Mallory 1000 Metal should be considered for use in balance weights and rotors whenever space is a factor.

In addition to important savings in space, you will also profit by Mallory's contour pressing technique which produces intricate shapes to close tolerances that minimize finish machining.

For complete specifications and characteristics, write for Technical Bulletin 6-7. It may be your answer for an improved product.

Expect more . . .
***Get more from* MALLORY**

Serving Industry with These Products:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
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For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

For more information, turn to Reader Service Card, Circle No. 336

FAIRPRENE®

synthetic elastic compositions

MATERIAL ENGINEERING SERVICE

SHEET STOCKS • COATED FABRICS • INDUSTRIAL ADHESIVES

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Now Du Pont is working with major companies to develop silicone-rubber FAIRPRENE compositions

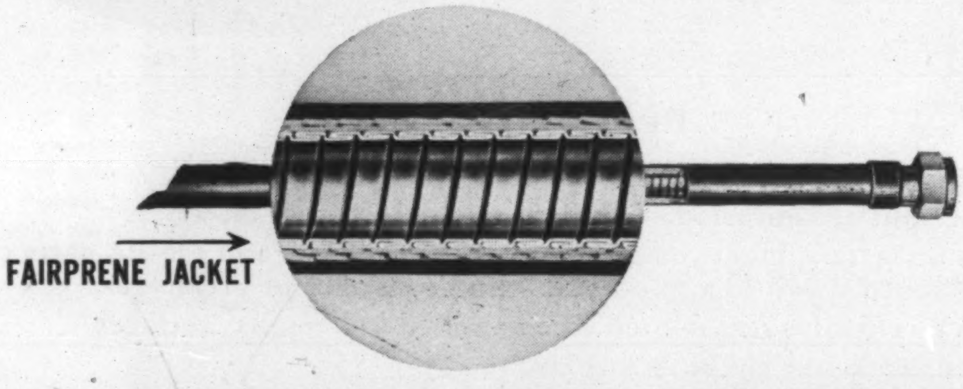
To meet severe high- and low-temperature operating requirements, tests are being conducted on Du Pont "Fairprene" synthetic elastic compositions made with silicone rubber on glass fabrics. These silicone-rubber compounds show excellent adhesion to the glass fabrics, and form an extremely dense, tough, rubbery film. The end uses in mind in these tests include, among others, airplane rocker-arm gaskets, engine baffles and air-duct coverings. The compositions being tested will have to stand up to such demanding service conditions as temperatures of 350°F. and continual flexing.

Du Pont's method is to work together with manufacturers in preparing specifications for silicone-rubber products, and then develop "Fairprene" compositions that will meet the manufacturers' needs. This work-together method assures customers of getting the specific grade of "Fairprene" that will do the job. It's a service *you* can call on, too.

Silicone rubber is just one of the elastomers used for "Fairprene." Other "Fairprene" compositions are made by impregnating, spreading or calendering elastomers on one or both sides of a woven fabric. The elastomer can be Neoprene, Buna-N, Buna-S, Butyl, or Thiokol—or a combination of these. The fabric can be cotton, "Orlon", nylon, rayon, glass, felt, asbestos, or some other fabric.

The general properties of "Fairprene" compositions—which can be "tailored" to fit your needs—include resistance to petroleum oils, greases, alcohol . . . to natural aging in air and oxygen . . . to extremes of heat and cold . . . to flex fatigue . . . to deteriorating action of fresh and salt water.

"Fairprene" is Du Pont's registered trade-mark for its line of products made from synthetic elastomers available in form of coated fabrics, sheet stocks without fabric insert and adhesives.



Close-fitting jacket of FAIRPRENE protects aircraft conduits

A moisture-proof jacket of tough Du Pont "Fairprene" protects Aircraft Shielding Conduits made by the American Metal Hose Branch of American Brass Company. As shown in the photograph, the molded "Fairprene" jacket covers the double wire braids over the four-wall flexible metal core of the conduit.

These conduits serve as aircraft engine spark-plug leads, where they have to stand up to such rigorous conditions as pounding vibration, extremes in temperatures and exposure to moisture. The "Fairprene" composition used was chosen for its ability to meet just such demands. It resists abrasion, withstands vibration, won't deteriorate in contact with oil or gasoline, keeps its toughness and flexibility at low and high temperatures.

Since this "Fairprene" composition is molded directly onto the conduit, it forms a tight, uniform, lightweight covering that needs no metal clamps.

This is another example of how versatile Du Pont "Fairprene" is already serving industry in many ways, with new applications being developed daily. Among the uses in which "Fairprene" compositions have proved successful are sensitive diaphragms, all types of gaskets, weather-stripping adhesives, apron and protective cloth materials, water-tight seam sealants, grease seals, oil-line coverings—and others too numerous and varied to fit here.

TECHNICAL HELP FOR YOU

Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products, or for improving your present products or manufacturing processes. They'll gladly work with you in engineering special grades of "Fairprene" to fit your specific needs. For prompt assistance, fill out and mail the coupon today.

"Engineered to do the job better"

SEND COUPON TODAY FOR INFORMATIVE BOOKLET ON "FAIRPRENE"

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, Fairfield, Conn.

☐ Please send me your free booklet on "FAIRPRENE"

☐ I am also interested in new "Fairprene" silicone-rubber compositions

☐ I am interested in learning more about Du Pont technical assistance. (No obligation, of course.)

*Name*____________________ *Title*__________
*Firm*____________________________
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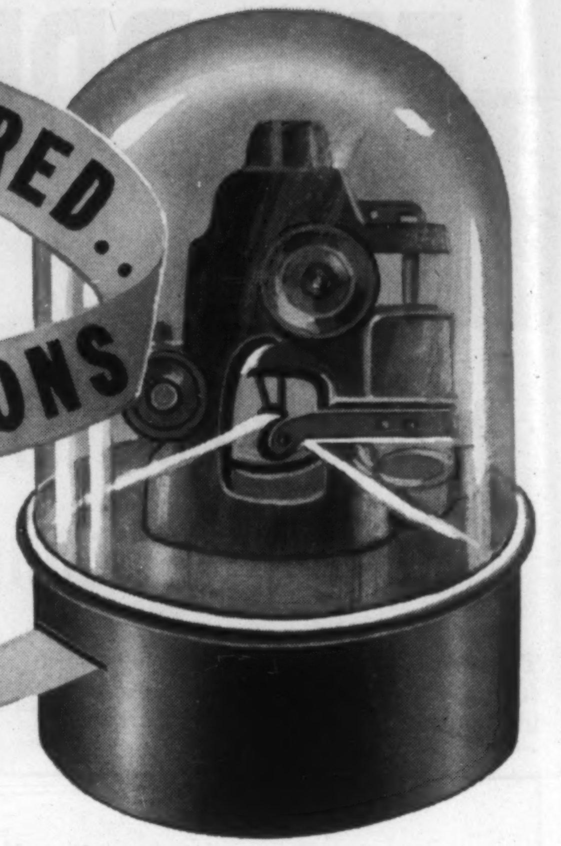
....RUBATEX ALWAYS PREFERRED... FOR GASKETING APPLICATIONS



Some of the Many Manufacturers Now Using Rubatex for Gasketing Applications:

Arvin Industries, Inc.

Boeing Airplane Company

Chrysler Corporation

Eaton Manufacturing Company

The Electric Auto-Lite Company

Enardo Manufacturing Company

Ford Motor Company
  Ford Division
  Lincoln-Mercury Division

Packard Motor Car Company

Piper Aircraft Corporation

Seeger Refrigerator Company

Servel, Inc.

Western Electric Company, Inc.

Willys Motors, Inc.

For air that protects —use Rubatex!

Production-wise

Soft, pliable, light in weight, easy to work with
Can be split or laminated — easily cemented to other materials
Takes up large dimensional tolerances so that glass and plastic parts can be tightened down to a good seal with no danger of breakage
Forms an effective seal — even when applied to irregular surfaces
May be cut to any shape — any size
Offers greater resiliency than other soft rubber materials
Shuts out dirt, moisture, oxygen — even at cut edges

Dollar-wise

Most gasket requirements can be cut from sheet stock in soft, medium or firm grades — ready for immediate shipment
Eliminates any need and expense of special coating or molded-on skin
Cheaper and more dimensionally accurate than molded parts

Performance-wise

Serving more and more industries in so many ways as:
Positive weather seal for auto light assemblies
Effective vapor seal for hatches for oil storage tanks
Air tight, water-tight construction joints
Weather stripping in aircraft stabilizer assemblies
Cushioning effect in hearing aids
Dust-proof seals in electronic devices and precision instruments
Sure-tight insulating seals for refrigerating and air-conditioning equipment

Why not give Rubatex a test? Send details of your specific application, and we'll send samples and recommendations. Write Dept. MM-6, Great American Industries, Inc., Rubatex Division, Bedford, Virginia.

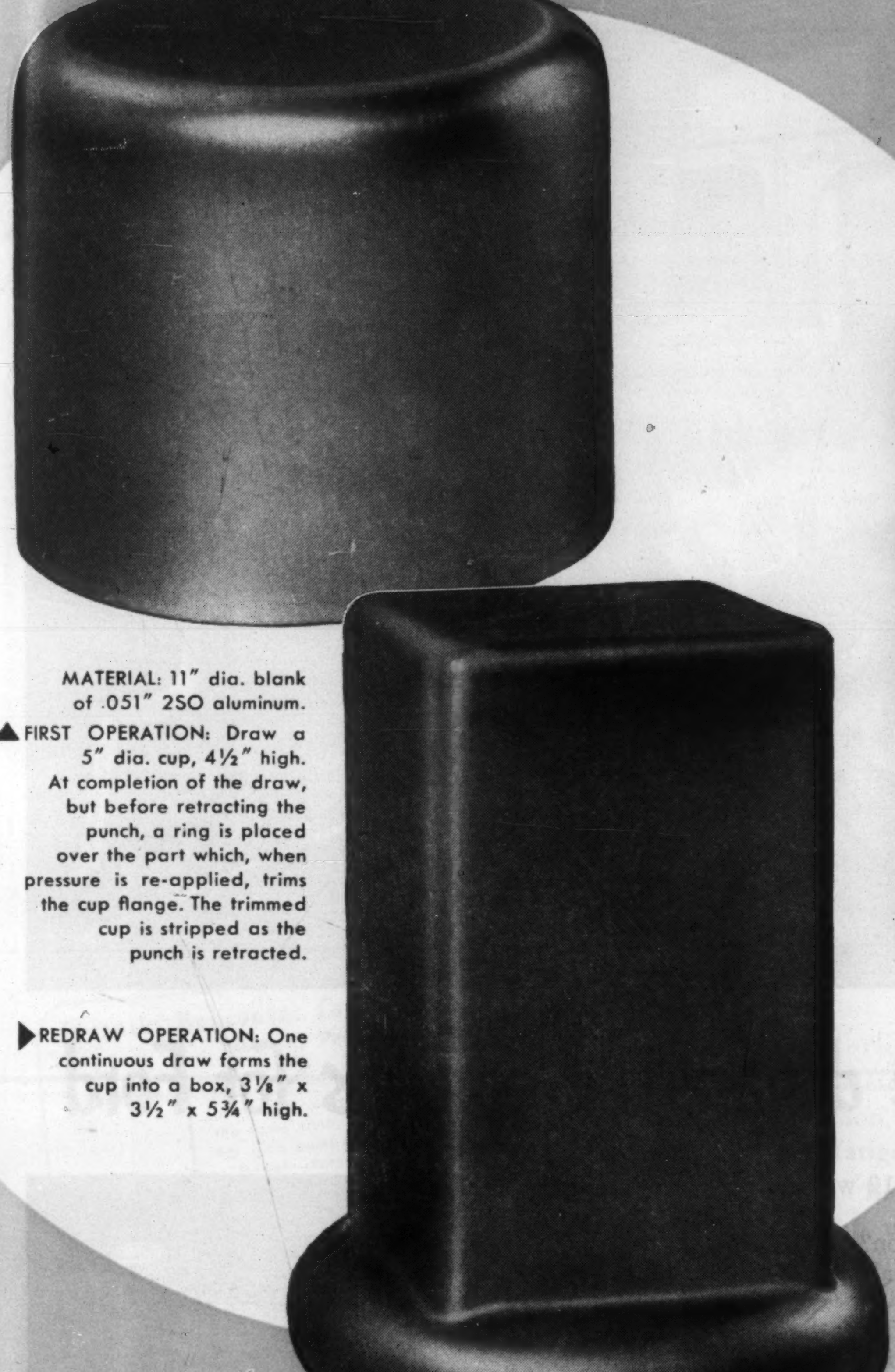
ALSO MANUFACTURERS OF VINYL SHEETS

PIONEER MANUFACTURER OF CLOSED CELLULAR RUBBER ©

RUBATEX CLOSED CELLULAR RUBBER

For more information, turn to Reader Service Card, Circle No. 329

redrawing a round into a square by Hydroforming



MATERIAL: 11″ dia. blank of .051″ 2SO aluminum.

▲ FIRST OPERATION: Draw a 5″ dia. cup, 4½″ high. At completion of the draw, but before retracting the punch, a ring is placed over the part which, when pressure is re-applied, trims the cup flange. The trimmed cup is stripped as the punch is retracted.

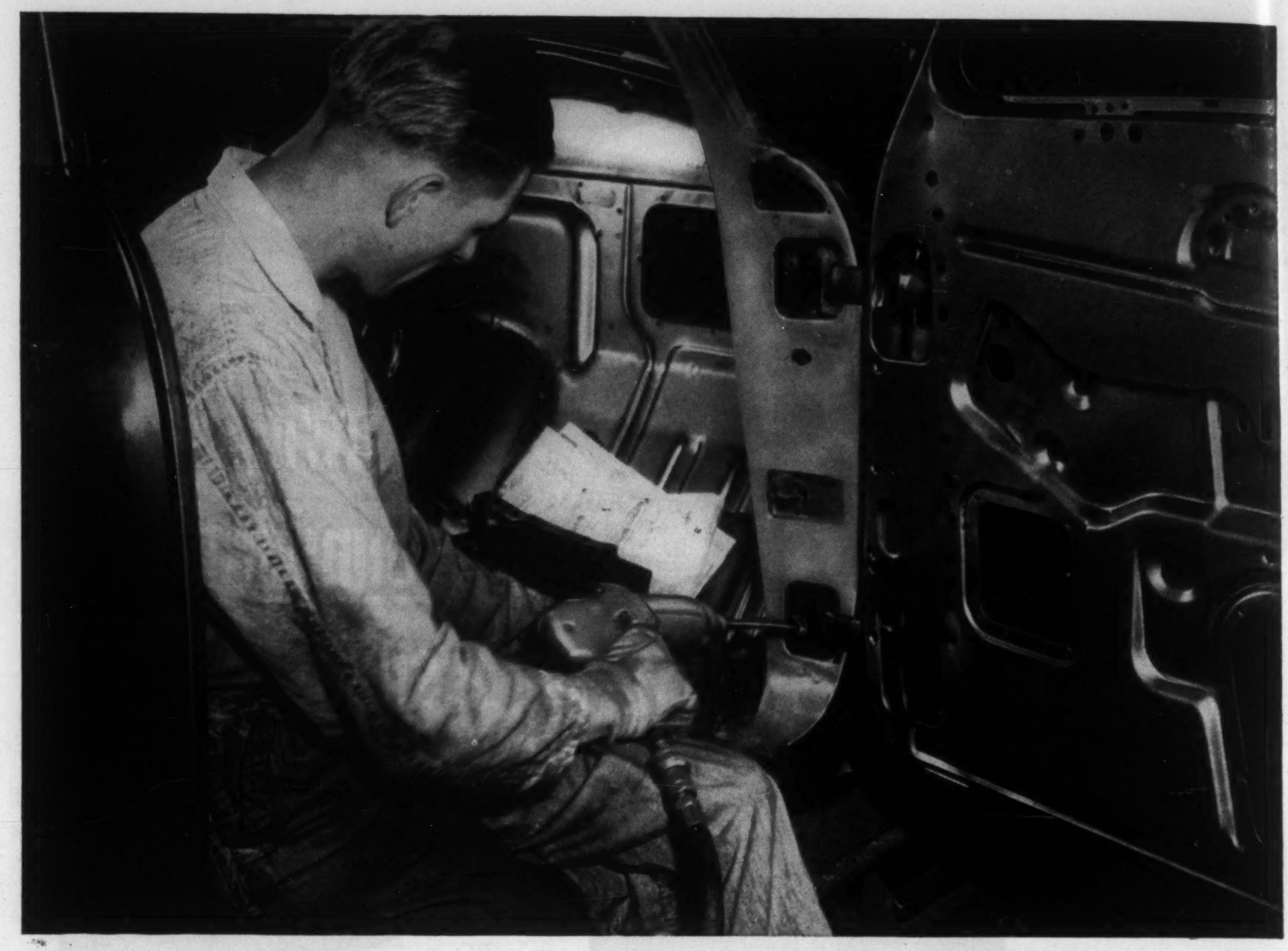
▶ REDRAW OPERATION: One continuous draw forms the cup into a box, 3⅛″ x 3½″ x 5¾″ high.

Here's a dramatic, new *switch* to the "can't fit a square peg into a round hole" story . . . the Cincinnati 12″ Hydroform version: Draw a round cup, then redraw it, producing a deep, rectangular box!

Try this on your draw press in *two forming operations* . . . then compare your conventional tools—their cost and complexity—with these: A punch and a draw ring to produce the cup . . . a ring to trim the cup flange . . . a redraw sleeve with square opening, which is placed into the first operation draw ring to accommodate the predrawn cup . . . and a finish punch to form the box. Of these five, simple Hydroform tool elements, only the finish punch and the internal opening of the redraw sleeve could not be machined on a lathe.

This is another example of the *unique* drawing action—the *simplicity* and *economy* of tooling—the *savings* of operations—made possible by Hydroforming. Can your company use these Hydroforming advantages? Find out now, by calling in a Cincinnati Milling field engineer. For a description of the Hydroforming process and specifications of the 12″, 19″, 23″, 26″ and 32″ machine sizes, write for Bulletin M-1759-2.

CINCINNATI **Hydroform** **THE CINCINNATI MILLING MACHINE CO.**
CINCINNATI 9, OHIO, U.S.A.



How we opened the door to lower costs for Ford

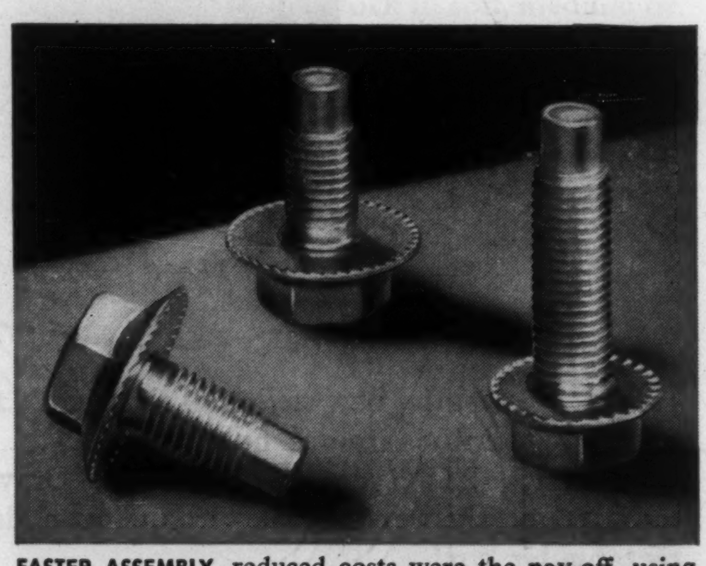
Two hinges on every Ford door. Six screws and 12 washers for each hinge.

Did this present an opportunity for cost reduction? An RB&W "fastener engineer" thought so. And after careful analysis and time studies Ford engineers agreed.

The solution: RB&W Hex SPIN-LOCK screws to fasten the hinge to the door, eliminating the need for washers. And special wide-flange Hex SPIN-LOCK screws for attaching the hinge to the frame, doing away with more washers. The wide flange is necessary to cover an elongated hole in which the hinge moves to permit accurate alignment.

Result — parts requirements are cut by two thirds, assembly is simplified, purchasing and inventory costs are lowered. And RB&W SPIN-LOCK screws hold those door hinges tight for good.

We will be glad to send an RB&W man around to check up on your fastening operations. Every problem is different, of course, but RB&W has a fastener for just about every job. If you need a "special", as Ford did, we'll design and make it for you. Write RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY, Port Chester, New York.



FASTER ASSEMBLY, reduced costs were the pay-off, using RB&W designed wide-flange SPIN-LOCK screws (left) for door hinge. Other SPIN-LOCKS (right) hold hinge on door. SPIN-LOCK screws *can't loosen* because ratchet-like teeth lock into surface and hold tight.

3.10

RB&W

109 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: PORT CHESTER, N.Y.; CORAOPOLIS, PA.; ROCK FALLS, ILL.; LOS ANGELES, CALIF. *Additional sales offices at:* ARDMORE (PHILA.), PA.; PITTSBURGH; DETROIT; CHICAGO; DALLAS; SAN FRANCISCO. *Sales agents at:* PORTLAND, SEATTLE. *Distributors from coast to coast.*

For more information, turn to Reader Service Card, Circle No. 340

Tandem-rotored six-place craft with large rescue hatch. Its mission — search and rescue; utility transport.

SAVE YOURSELF

from costly, excessive wear

... with AMPCO* METAL

Piasecki Helicopter Corporation
Morton, Pennsylvania

Problem: To find a material that withstands severe shock loads, high operating speeds, corrosive action of the elements and, at the same time, provides good bearing qualities when needed for such parts as:

Dowel—Rotor Blade Leading Edge, Bushing—Trim Mechanism, Bearing—Collective Pitch Lever Flange, Bearing—Collective Pitch Lever Grip, Bushing — Flexible Shaft Coupling, Support Assemblies — Power Plant Controls, Fuel Shut-Off, Swivel Details, Washer—Rescue Hatch Actuator, and many other components.

Solution: AMPCO METAL

Results: The performance of Piasecki helicopters under all kinds of conditions is proof of the life-saving dependability of these units. The ability to "take it" has established Piasecki as a leader in the development of transport helicopters.

IT'S PRODUCTION-WISE TO AMPCO-IZE

HERE are the properties of Ampco Metal that appeal to designers and plant-operating men — properties that increase the service life of machines, and reduce upkeep costs:

High compressive strength — Ampco Metal doesn't squash out . . . High resistance to corrosion, erosion, and abrasion . . . High impact and fatigue values . . . Excellent bearing qualities.

Because Ampco Metal has this ability to stand up under the severest kind of service, leading companies, like Piasecki Helicopter Corporation, use this outstanding aluminum bronze alloy to provide an extra margin of safety and dependability.

If you have a wear problem in either product or plant, investigate the cost-saving properties of Ampco Metal. You can get it in practically any form you need — sheet, plate, sand and centrifugal castings, forgings, bars, tubes, welding wire and electrodes. For further information consult your nearest Ampco field engineer or send this coupon.

*Reg. U. S. Pat. Off.

Ampco Metal, Inc.
MILWAUKEE 46, WISCONSIN
West Coast Plant:
BURBANK, CALIFORNIA

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Send me your free Ampco Metal literature giving descriptions and general applications of Ampco Metal.

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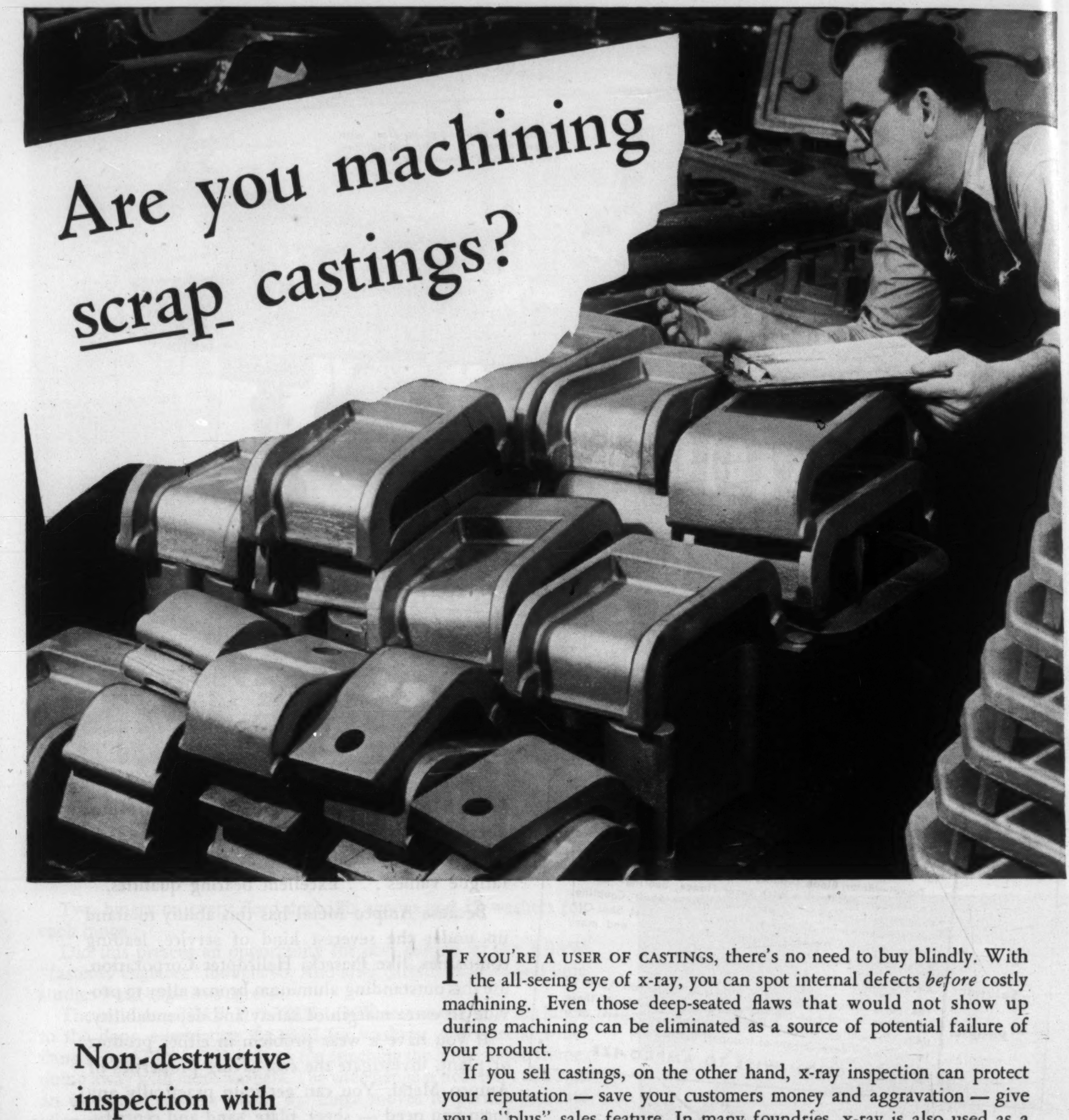
D-12A

For more information, turn to Reader Service Card, Circle No. 395

Are you machining *scrap* castings?



Non-destructive inspection with a G-E x-ray unit insures a better product at lower cost

IF YOU'RE A USER OF CASTINGS, there's no need to buy blindly. With the all-seeing eye of x-ray, you can spot internal defects *before* costly machining. Even those deep-seated flaws that would not show up during machining can be eliminated as a source of potential failure of your product.

If you sell castings, on the other hand, x-ray inspection can protect your reputation — save your customers money and aggravation — give you a "plus" sales feature. In many foundries, x-ray is also used as a development tool — to disclose where savings can be made, designs improved, new techniques developed.

The possibilities for the profitable application of x-ray are as broad as industry itself. In addition to castings — weldments, intricate assemblies, the composition of the materials themselves can be checked.

Your G-E x-ray representative will be glad to analyze your requirements. With General Electric's line of 25 models, he can recommend the unit best suited to your needs. Call him today, or write X-Ray Department, General Electric Company, Milwaukee 1, Wis., Rm. AZ64.

General Electric x-ray apparatus can be yours . . . without initial capital investment . . . on the G-E Maxiservice® rental plan

You can put your confidence in —

GENERAL ELECTRIC

For more information, turn to Reader Service Card, Circle No. 339

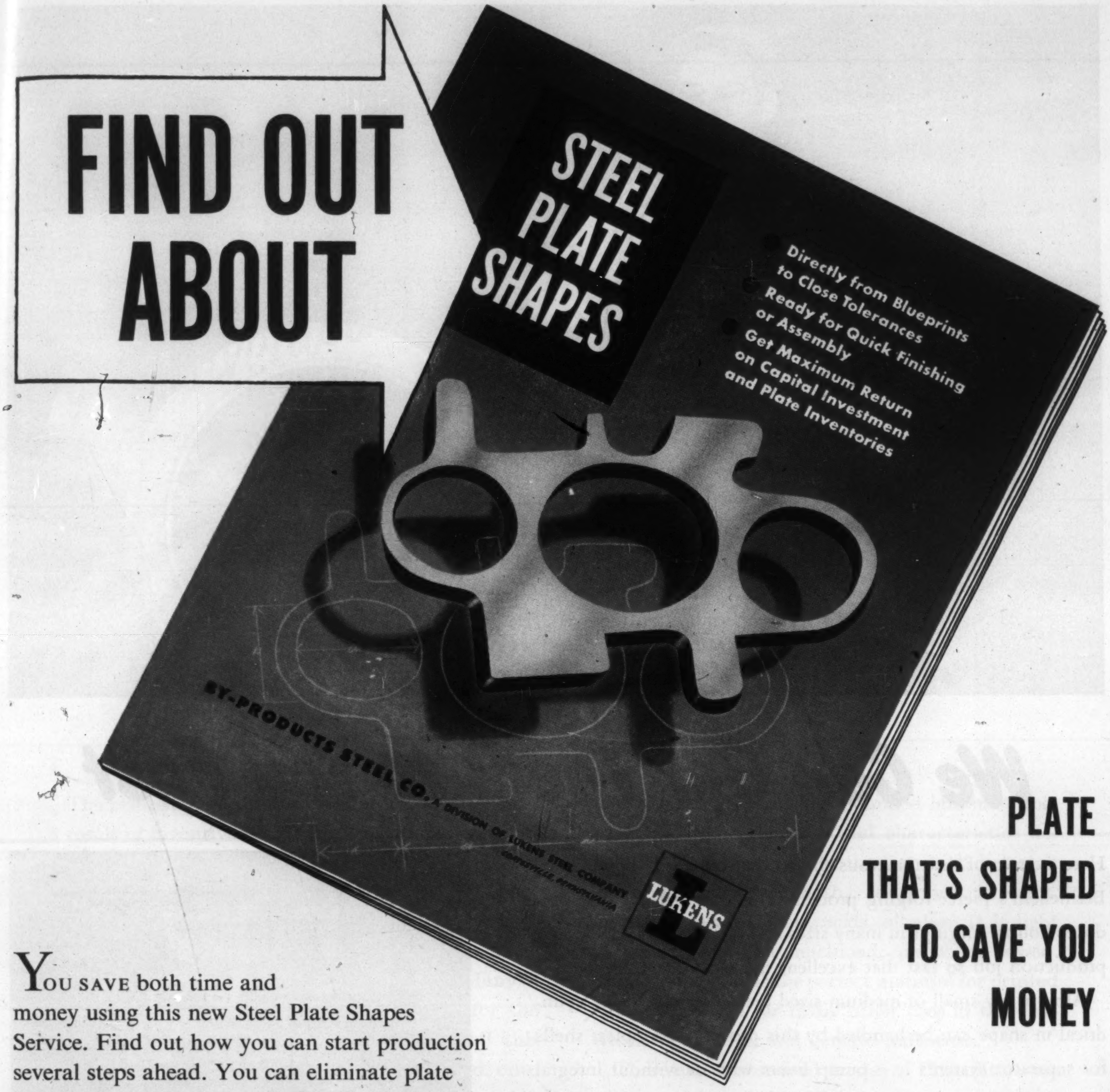

FIND OUT ABOUT
STEEL PLATE SHAPES
Directly from Blueprints to Close Tolerances
Ready for Quick Finishing or Assembly
Get Maximum Return on Capital Investment and Plate Inventories
BY-PRODUCTS STEEL CO., A DIVISION OF LUKENS STEEL COMPANY
COATESVILLE, PENNSYLVANIA
LUKENS
L

PLATE THAT'S SHAPED TO SAVE YOU MONEY

YOU SAVE both time and money using this new Steel Plate Shapes Service. Find out how you can start production several steps ahead. You can eliminate plate inventories, and you pay freight only on that part of the plate that is actually required.

There's no need to invest in new cutting and forming equipment for your own shops. We have over 150 major machines to flame-cut, shear, blank, press, bend or otherwise form steel plate.

This new Bulletin 712 shows how Steel Plate Shapes Service can help you. For a free copy, use this coupon or write on your company letterhead.

BY-PRODUCTS STEEL CO.
Division of Lukens Steel Company
674 Strode Avenue, Coatesville, Pa.

Please send me a free copy of Bulletin 712.

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BY-PRODUCTS STEEL CO.

A DIVISION OF
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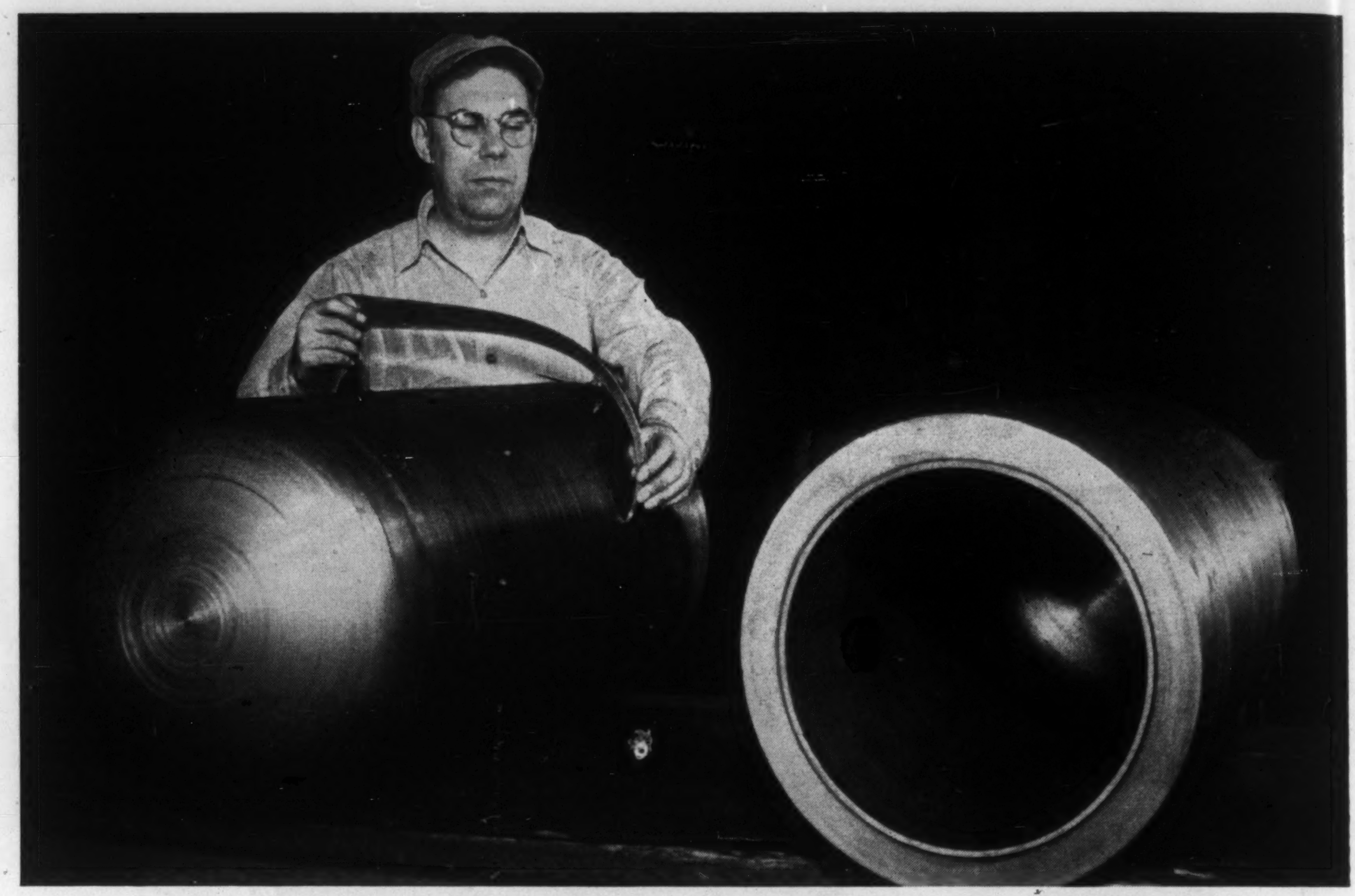


We Can Get Them to You Fast

Here are two of the numerous shapes that can easily be made by Bethlehem's pierce-forging process. This is a method that produces hollow forgings in many sizes and types, and that does the production job so fast that excellent deliveries are possible.

Almost any small or medium-sized piece that is roughly cylindrical in shape can be handled by this process. Examples: shells for separator systems . . . pump liners with or without integral collars . . . nozzles, journal forgings, commutator shells, etc.

Bethlehem pierced forgings are available in carbon or alloy steel, heat-treated or untreated. They are furnished rough-machined so that the customer is saved a costly operation in his own plant. And they're economical, too—something we'll be glad to prove by quoting on your needs.

Why not ask for full details? These sturdy, low-cost forgings have many advantages that could be useful to you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

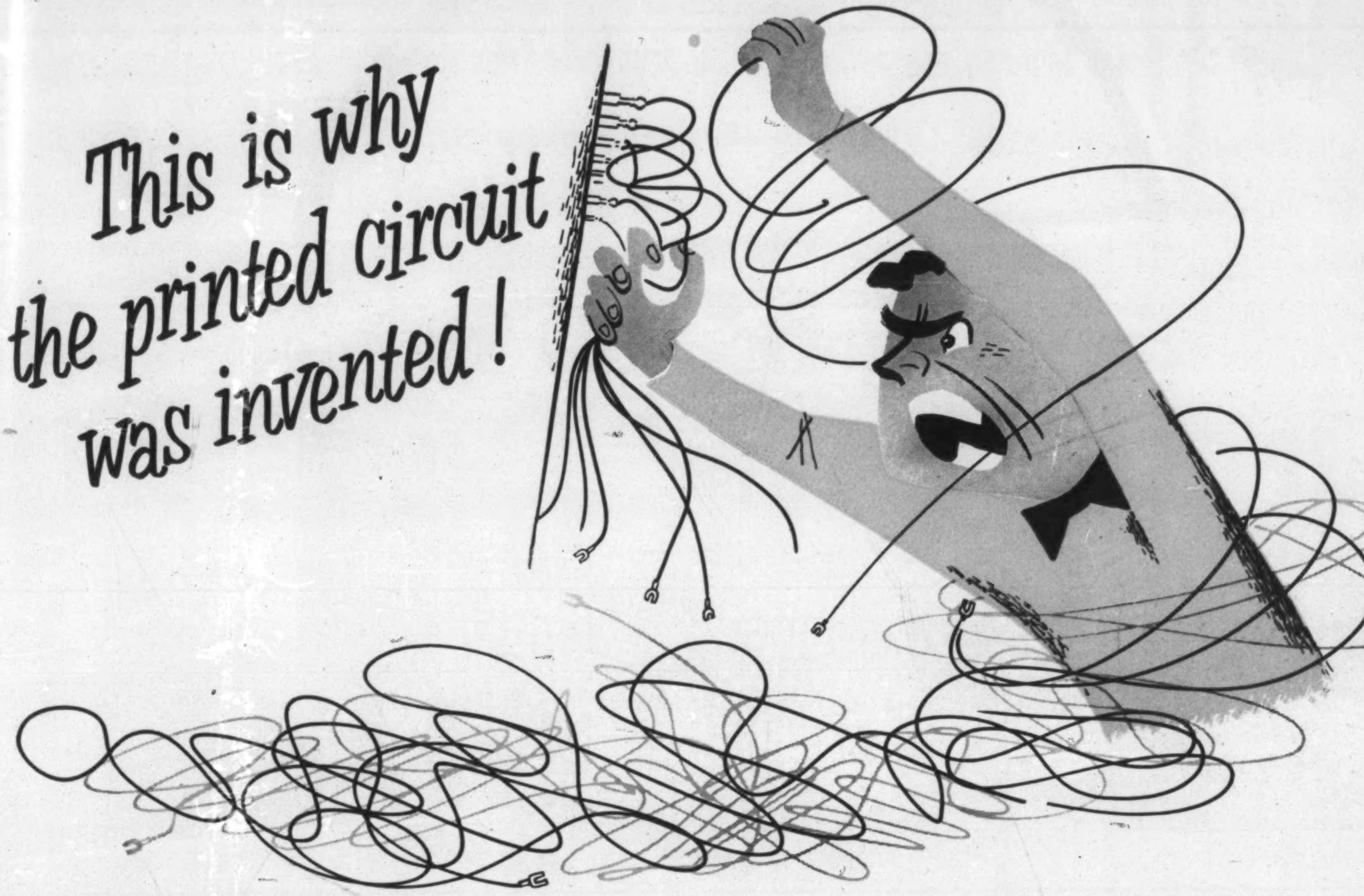
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM FORGINGS

BETHLEHEM STEEL

For more information, turn to Reader Service Card, Circle No. 357

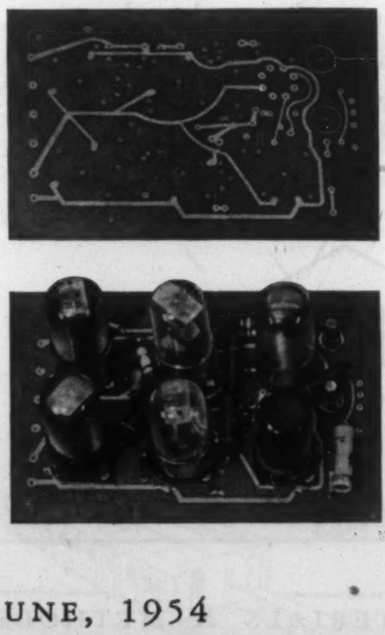
This is why the printed circuit was invented!



The printed circuit is the inevitable and successful result of inventive man's effort to do old things in new and better ways. The old way of installing an electrical circuit, in such fields as radio, television, hearing aids, automatic signals and other low-power applications, was a slow, expensive hand-process which was susceptible to error. Many a complex system had real nuisance value for the manufacturer. The new way eliminates all this because the circuit itself is etched, or printed, onto a sheet of copper foil bonded to a base material.

Copper-Clad Phenolite—by National—holds the secret of success in printed circuits. The Phenolite core is a scientifically compounded laminate possessing *all* the properties and characteristics demanded for the job. Among these are high dielectric and mechanical strength, resistance to heat, moisture, solvents, oils, acids, alkalies. It is light in weight—can be machined, punched, sawed, drilled. Phenolite is the perfect material for printed circuits . . . and for many other uses in the electrical, electronics, and general industries.

There are 35 standard grades of Phenolite, each with special qualities. May we demonstrate their value to you . . . show you how these remarkably versatile materials can help you?



PRINTED CIRCUIT . . . THE NEW WAY!

(Top) Copper-Clad Phenolite showing the etched conductor pattern for an audio amplifier. (Bottom) Here is the same etched circuit with tubes and other components in place. We have a complete bulletin crammed with ideas and data about our laminated plastics. May we send you a personal copy? Address Dept. D-6.

NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

PHENOLITE
Laminated PLASTIC

Also manufacturers of Vulcanized Fibre, Vul-Cot Waste Baskets, Peerless Insulation, Materials Handling Equipment and Textile Bobbins.

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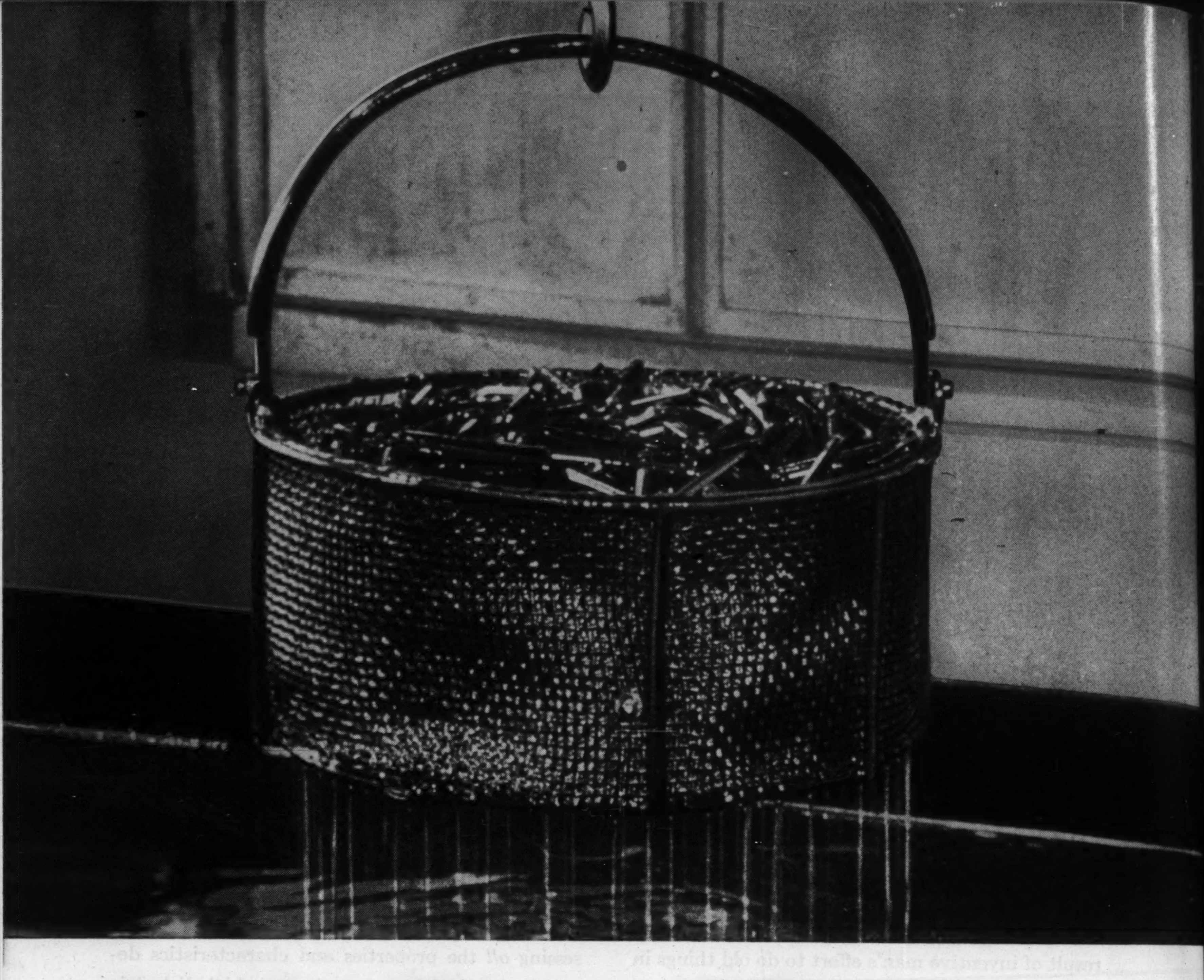

You Get Minimum Drag-out with Sun Quenching Oil Light

When you reduce oil consumption by lowering drag-out, you cut a major cost in operating a quenching system. Sun Quenching Oil Light thins out when heated, drains off parts faster and more completely. And Sun Quenching Oil Light, because of its natural detergency, prevents the formation of sludge deposits, aids in removing any deposits that have accumulated. And under normal operating conditions it need never be replaced. Sun's booklet "Sun Quenching Oils" tells about this low-cost oil. For a copy, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. ML-6.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

SUNOCO ®

PHILADELPHIA 3, PA. ◆ SUN OIL COMPANY LTD., TORONTO & MONTREAL

Made by the producers of famous Blue Sunoco Gasoline and Dynalube Motor Oils

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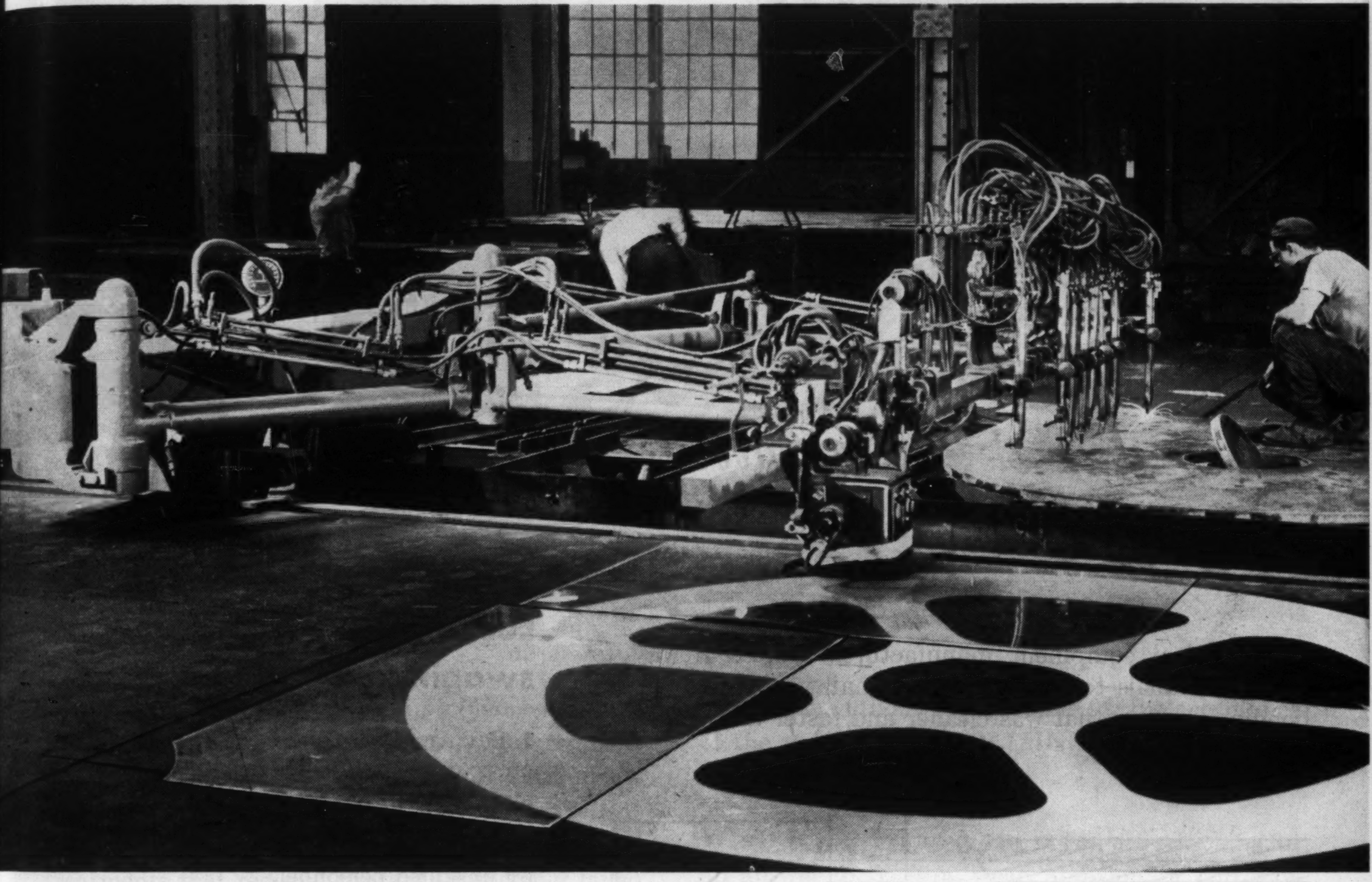
CONTINENTAL

STEEL FABRICATIONS AND WELDMENTS

Components or Assemblies



Custom or Production?—Save time and Money!

Here's one reason why Continental-made weldments can save you time and money. This multi-head flame cutter, guided by an electric eye, can cut up to eight shapes at once—from any metal that can be burned with oxygen or oxygen and powder. Working from paper templates, it saves pattern costs.

For welded components or complete assemblies—one of a kind, or quantity production—Continental's modern equipment and methods offer you design flexibility and production economy.

WRITE

for this new Brochure M on Continental Weldments.

COMPLETE ROLLING MILLS • ROLLS
STEEL CASTINGS • WELDMENTS
BOILER CONTROLS AND CLEANING

Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
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CONTINENTAL
Foundry & Machine
Company

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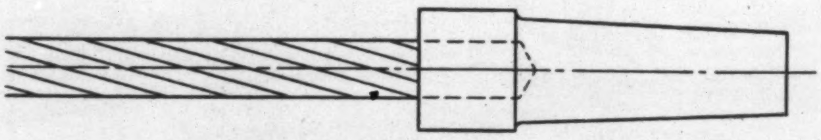
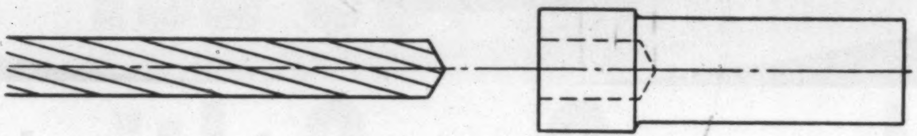
Swaging
Success
Stories

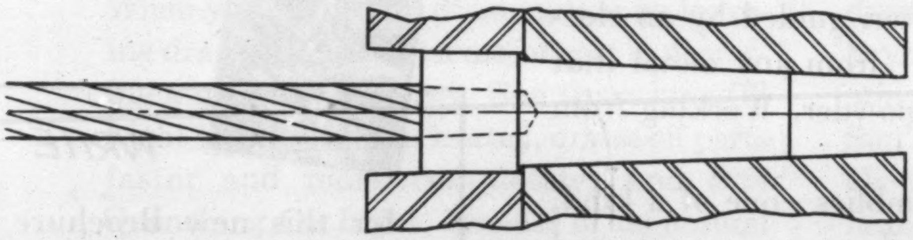
Cable Swaging…
Clean, Quick, Economical



An electrical equipment manufacturer wanted a way to fasten terminals to cables—a way that would give perfect bonding—a way that was cleaner and faster than soldering or brazing.



Torrington's swaging experts showed him how to attach terminals to cables by one fast rotary swage.



Result: a clean, secure joint between cable and terminal, and accurate sizing of the plug end of the terminal at the same time.

Look at the savings that swaging can bring!

1. Savings in material and equipment—no solder, no brazing or dipping equipment needed.
2. Savings in labor—swaging can be done by unskilled personnel.
3. Savings in time—swaging is fast, clean and precise.

For more information on swaging as a method of bonding or reducing metals write for our informative booklet. It contains complete descriptions of the Torrington Rotary Swagers and may give you some ideas for a "swaging success story" in your own plant.

THE TORRINGTON SWAGING MACHINE
The Torrington Company

THE TORRINGTON COMPANY
Swager Department
660 North Street, Torrington, Conn.
Makers of Torrington Needle Bearings

TORRINGTON ROTARY SWAGING MACHINES

For more information, turn to Reader Service Card, Circle No. 331

Electrolizing
CASE HISTORY NUMBER 642
Aircraft Parts Manufacturer
Reduces Friction
50%
WITH Electrolizing

The Problem: Serious friction problems were preventing the acceptance of a unit manufactured by a nationally known producer of aircraft equipment. Electrofilming, chrome plating and other excellent surface treatments were tested without success. The treatments that reduced friction appreciably failed to meet the corrosion specification. Those that provided the required corrosion resistance failed to reduce friction within the required limits.

How it was solved: Following a meeting held with the engineers responsible for the project, ELECTROLIZED parts were tested. Friction was reduced by 50% and the 100-hour salt spray requirement was met. Repetitive tests established the consistency of ELECTROLIZING to the satisfaction of the authority responsible for the acceptance of the unit. ELECTROLIZING was incorporated in the drawing.

What it means to you: If you are searching for an answer to friction, wear, abrasion, or corrosion problems, ELECTROLIZING is the ideal starting point.

At no cost and without sacrificing project time, you can quickly appraise this process in terms of your own needs. Our 16-page booklet will help you. It describes some of the difficult engineering problems that have been solved with ELECTROLIZING. Just return the coupon for your copy. There is no obligation.

THE Electrolizing CORPORATION

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THE ELECTROLIZING CORPORATION
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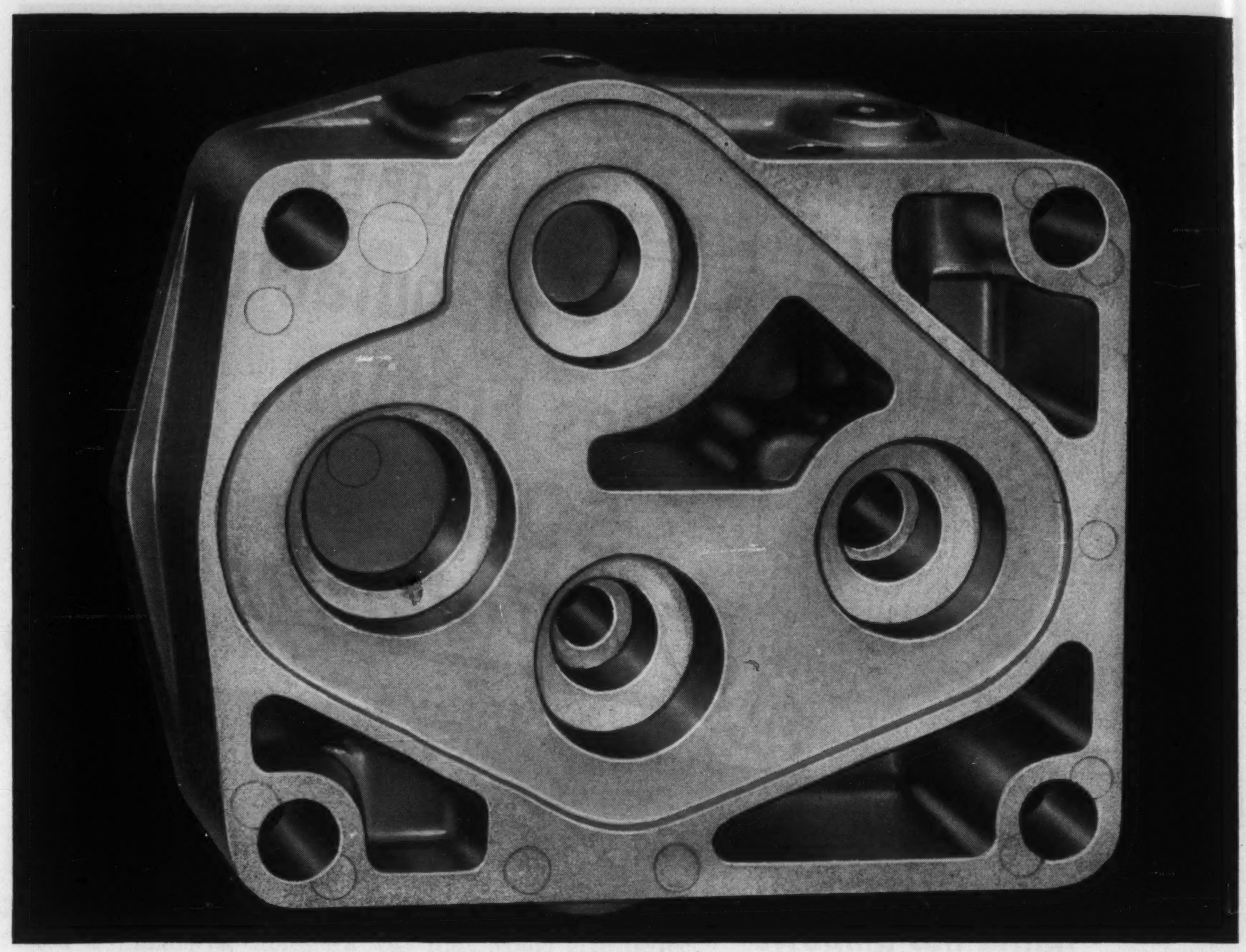
Please send me the 16-page Electrolizing booklet:

Name ....
(Please Print)
Company ....
Address ....
City .... *State* ....

For more information, turn to Reader Service Card, Circle No. 372



GRADE A DESIGNING

with MADISON-KIPP

zinc and aluminum die castings

Only a highly qualified engineer would be assigned the job of designing a selector valve like the one here illustrated. He can often do his best work by also utilizing the seasoned skill of Madison-Kipp craftsmen. Please note the significant coring so vital to valving. There is Grade A Designing involved by both the principal and die casting contractor—Madison-Kipp.

We will welcome your inquiries.

kipp

MADISON-KIPP CORPORATION
218 WAUBESA STREET • MADISON 10, WIS., U.S.A.

- **Skilled in Die Casting Mechanics**
- **Experienced in Lubrication Engineering**
- **Originators of Really High Speed Air Tools**

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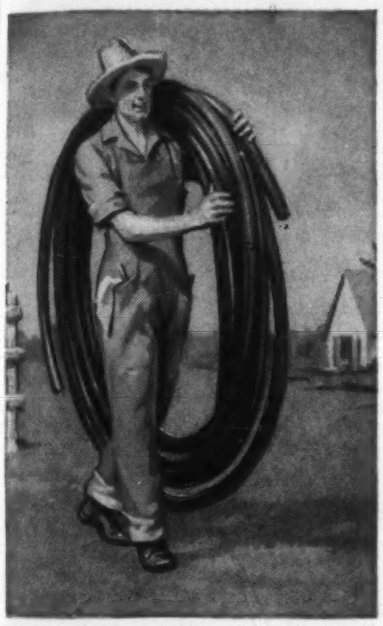
For more information, Circle No. 493 ➤

Put the powerful advantages of BAKELITE Polyethylene to work for your products

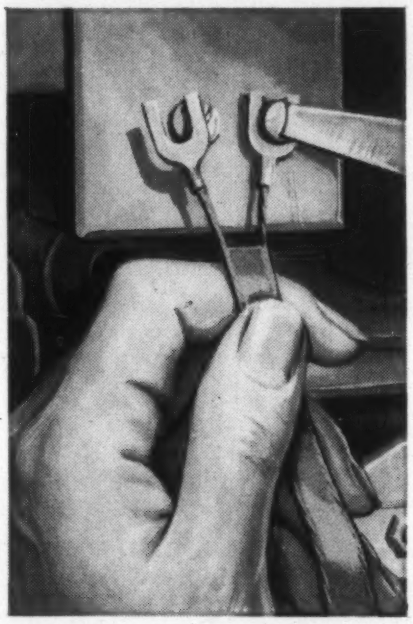
TRADE-MARK

Do you need LIGHT WEIGHT?



Polyethylene is the lightest of all plastics. With Bakelite *Polyethylene* you can make products easier to use, less costly to ship and handle. Look at this 2-inch water pipe. One man carries a 200-ft. coil with ease . . . no rigging needed. There's no rusting, no electrolytic action, no damage from freezing. There's high resistance to corrosion.
Imagine how many ways this lightweight, durable, and easily-fabricated material can help *you.*

Do you need SUPERIOR INSULATION?

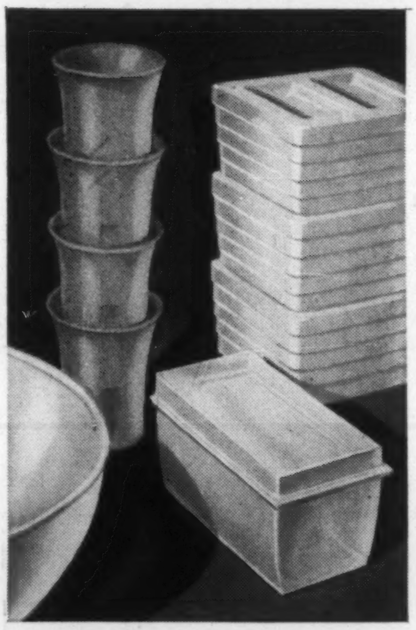


Bakelite *Polyethylene* is the superior insulating material preferred for low-loss television lead-ins. It makes wire and cable much lighter, more weather and chemical resistant. It gives your engineers a highly-adaptable material for a wide range of uses . . . as a potting resin . . . as color-coded wire and component insulation . . . for gaskets, stand-offs and scores of other electronic products. And now, Bakelite *Cellular Polyethylene,* expanded with inert gas, offers even lighter weight, superior properties for VHF and UHF, and makes a pound of polyethylene go almost twice as far.

Do you need FLEXIBILITY?

Bakelite *Polyethylene* has such inherent flexibility that no plasticizers are needed! There's flexibility with shape retention . . . for squeeze bottles of any color, with frosty, translucent, metallic or other sales-appealing finishes. It makes highly-flexible transparent film for packaging foods and scores of other products. The resins make an excellent wax additive for bread and baked-goods wrappers, providing greater strength, better heat sealing, glossier printing.

Do you need STABILITY?



Bakelite *Polyethylene* is inert. It doesn't impart odor or taste. It's ideal for refrigerator containers, bowls, food packages, clothing and textile bags, and scores of other uses. In fact, it's chemically inert to almost all substances. From unbreakable carboys that safely carry corrosives . . . to spillproof and leakproof bottles for drugs . . . to chemical pipe and tubing . . . Bakelite *Polyethylene* can help you make, sell, and distribute your products better, easier, and more profitably.

RIGHT NOW is the time to put Bakelite *Polyethylene* to work for your present products and your products-in-mind. It can be fabricated in every way nown to plastics. It offers opportunities hat no one can predict until he tries it. tart investigating now by writing for ur booklet, Bakelite *Polyethylene,* to Dept. XK-17.

BAKELITE Polyethylene

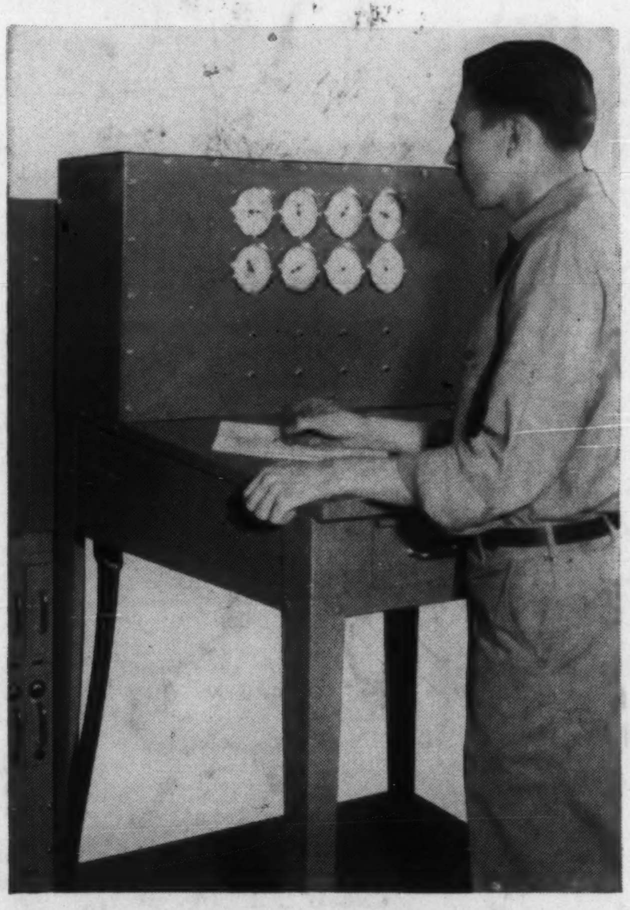
TRADE-MARK

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

For more information, turn to Reader Service Card, Circle No. 466

Why TIMKEN® forging steels give you uniform, high quality forgings

THIS MICROSCOPIC CHECK of your order makes sure that Timken® forging steels have uniform grain size after heat treatment. Result: higher ductility, higher impact. This is another example of the many ways the Timken Company controls quality at every step in production.



RIGIDLY CONTROLLED CHEMISTRY assures you of uniform composition in every forging bar. This spectrometer, for example, tells the exact composition of a melt in just 40 seconds. Results are flashed back to the furnace so the melter can maintain constant control of the heat analysis.

INDIVIDUAL HANDLING of your order enables us to target conditioning procedure to your forging requirements. Your forging rejects are minimized. And you save steel because the good dimensional tolerances of Timken bars produce uniform weight multiples with a minimum of steel lost in flashings.

YOU HAVE FEWER FURNACE ADJUSTMENTS when you use Timken forging steels. Every lot responds uniformly to heat treatment because every lot has the same physical and chemical properties. Always specify Timken forging steels. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

TIMKEN

TRADE-MARK REG. U.S. PAT. OFF.

Fine Alloy

STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

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